INTERAVIA

REVIEW OF WORLD AVIATION

Price of this issue:

U. S. A.:	80 cents
British Isles:	5 s.
Switzerland:	Fr. 2.80
Netherlands:	Fl. 3.—
Denmark:	d. Kr. 5.—
Germany:	DM 3.—
France:	Fr. 250
Italy:	Lire 410

IN THIS ISSUE

BOMBER PARADE

VOLUME VII 3 1952

18,600 miles across Africa

ALGIERS - CAPE TOWN - ALGIERS

Trans-Africa Record from Cape Town to Algiers

BUTTI AND RACCA IN 11 DAYS, 4 HRS. 54 MINS. (9,300 MILES)

(previous record : 3 days 15 hrs. 45 mins.)

On the ALGIERS-CAPE TOWN trip the Fiat "Campagnola" carried four persons and towed a 2,850-lb. trailer. The crossing of the Sahara (Hoggar trail) was made in record time: 6 ½ days.

INTERAVIA

Review of World Aviation

Volume VII — No 3 — 1952

Board of Directors: Marcel Devaud, Edgar Primault. Eugen Groh, E. E. Heiman, O. H. C. Messner, E. V. D. Wight, Jr.
Editors: E. E. Heiman, P. A. Blackburn, E. Herzfeld.
Assistant Editors: H. Rieck, A. de Rham, J. Jenni, A. Arbex, E. Baur, Ginés de Bracamonte, J. M. Stroud.
Art Editor: H. W. Mahrer.
Publishers and Distributors: Interavia S. A. **Proprietors:** Volamecum S. A.

Contents

BOMBER PARADE

The Jet Bomber Confounds the Air Strategists — P. M. GALLOIS, PARIS — 127
Know Your Bombers — 132
Chameleon Aircraft? — 137
Stalin's Global Bomber — 138
The Future Evolution of the Bomber — E. SÄNGER, PARIS — 139
Jet Bomber Squadron — 144

Titanium Takes the Test — 146
Artificial Satellites — Key to Space Flight? — L. N. THOMPSON, NEWCASTLE-ON-TYNE — 148
1952 Aviation Prospects (concl.) — 150
Aviation Shares on the New York Stock Exchange — 155
What's in the Air? — 157
Omni-Ranges for Long Distance Navigation — E. KRAMAR, STUTTGART — 159
Fire-Fighting at Airports — J. L. JACOB, PARIS — 162

Front Cover

"Canberra" light jet bombers of the R.A.F.'s No. 101 Squadron at Binbrook Station, Lincs. The "Canberra" is the kind of light bomber which might fit into Lieut.-Col. Gallois' definition of "the poor man's a-bomber" (see first article).

Appears Monthly in Four Editions: English, French, Spanish and German.

Advertising Department, Publishing and Editorial Offices, Subscription Department: Interavia S. A., 6, Corraterie, Geneva. Telephone: 5 42 34 (five lines). Cables and Telegrams: Interavia-Geneva.

Annual Subscriptions: Switzerland, Sw. frs. 28.00; U. S. A. and Canada, U. S. $7.00; Great Britain, 46/—; France, Fr. frs. 2,400; Belgium, Belg. frs. 360.00; Holland, Fl. 31.00; Germany, DM 28.00; Sweden, Kr. 35.00; Norway, Kr. 50.00; Spain, Ptas 275.00; Austria, ö. S. 170. All other countries: Sw. frs. 28.00.

Agents and Distributing Offices:

INTERAVIA AUSTRIA: Morawa & Co., Wollzeile 11, Vienna I.
INTERAVIA BELGIUM: 11, Rue de Crayer, Brussels, or Office de Publicité, 16, Rue Marcq, Brussels.
INTERAVIA BRAZIL: R. F. Besnard, 91 av. Almirante Barroso, S. 417-419, Rio de Janeiro.
INTERAVIA CANADA: Wm. Dawson Subscription Service Ltd., 60 Front Street West, Toronto, Ontario.
INTERAVIA DENMARK: Dansk Centralagentur, Stormgade 20, Copenhagen.
INTERAVIA FINLAND: Akateeminen Kirjakauppa, Keskuskatu 2, Helsinki - Rautatiekirjakauppa Oy, Köydenpunojank 2, Helsinki
INTERAVIA FRANCE: 144, Champs-Elysées, Paris VIIIe.
INTERAVIA GERMANY: Ausland-Zeitungshandel W. E. Saarbach, Frankenstrasse 14, Cologne-Junkersdorf. Postal Cheque Account Cologne 25823.
INTERAVIA GREAT BRITAIN: Interavia (United Kingdom) Ltd., 2-5, Old Bond Street, London, W. 1.
INTERAVIA HOLLAND: M. van Gelderen & Zn., Postbox 826, Amsterdam-C.
INTERAVIA IRELAND: Basil Clancy, Esq., Cooleevin, Foxrock, Co., Dublin.
INTERAVIA HUNGARY: Kultura, Akademia-utca, 10, Budapest, V.
INTERAVIA ISRAEL: F. Pinczower P.O.B. 6008, Tel-Aviv.
INTERAVIA ITALY: 30 Via San Marino, Rome.
INTERAVIA NORWAY: Narvesens Kioskkompani A.S., Box 125, Oslo.
INTERAVIA SOUTH AFRICA: P. O. Box 6073, Johannesburg.
INTERAVIA SPAIN: Litavia, Maestro Victorio 8, Madrid.
INTERAVIA SWEDEN: Postbox 29, Linköping.
INTERAVIA U.S.A.: 385 Fifth Avenue, Room 1408, New York 16, N. Y. Subscriptions also from the International News Co., 131 Varick Street, New York, N. Y.

Copyright 1952 by Interavia S. A., Geneva, Switzerland

Printed in Switzerland

Imprimeries Populaires, Geneva — Héliographia S. A., Lausanne
Imprimerie de "La Tribune de Genève", Geneva

for **AIRCRAFT MAINTENANCE**

Overhauls
Repairs
Conversions
Conservation
Integral Tank Resealing

avail yourselves of the SAS' skilled technical staff and modern well-equipped hangars and workshops.

A qualified specialist is available for consultation at your base, and we shall have pleasure in discussing with you any aspect of your aircraft maintenance. Whatever the type of work - you can depend on

SCANDINAVIAN AIRLINES SYSTEM

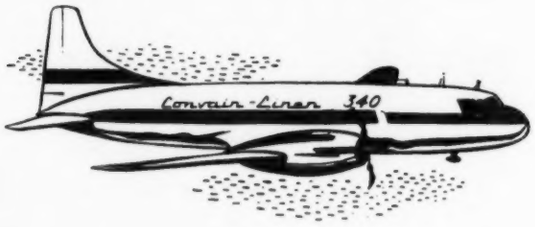
DENMARK - NORWAY - SWEDEN

Region - Denmark Copenhagen Airport - Kastrup

UNITED AIRGRAM

UNITED AIRCRAFT EXPORT CORPORATION

K.L.M. JOINS OTHERS IN PURCHASING CONVAIR 340s -- An announcement from Amsterdam in mid-January revealed that the Royal Netherlands Airline, K.L.M., has ordered six Convair 340 passenger planes from the United States to use in the West Indian service. The new aircraft will be added to K.L.M.'s fleet which already includes 12 Convair 240s.



This latest order brings the total of Convair 340s ordered for overseas lines to 29. Other airlines which have ordered the new airliners include: Aero O/Y, 3 aircraft; Philippine Airlines, 4; Compania Mexicana de Aviacion, 5; Aeronaves de Mexico, 3; and Garuda Indonesian Airways, 8; all are equipped with Pratt & Whitney Double Wasp Engines and Hamilton Standard propellers.

SIX B-36 BOMBERS IN NON-STOP TEXAS TO MOROCCO FLIGHT -- Pratt & Whitney Wasp Major engines, assisted by turbojet engines, powered the six Convair B-36 bombers of the U.S. Air Force's Strategic Air Command which recently flew non-stop from Carswell Air Force Base, Fort Worth, Texas, to the new Sidi Slimane Air Base in French Morocco. The return trip, which took place a week later, was also flown non-stop.

This achievement marked the first time that other than local flights had landed at the new field in French Morocco. The 4,984-mile homeward flight was made in 24 hours.

The 18 crewmen in each plane shrugged off the feat as routine. Their plane, the B-36, can fly a 10,000-pound bomb load 5,000 miles and return to base.

HAMILTON STANDARD COCKPIT REFRIGERATION UNITS IN DEMAND -- Substantial orders for cockpit refrigeration units have been received from the U. S. Air Force and the U.S. Navy by the Hamilton Standard Division of United Aircraft Corporation. The division's new product has been specified for installation in seven airplane types, including jet fighters and a turboprop transport.

U.S. Air Force aircraft for which the units are specified are the swept-wing North American F-86D and F-86H Sabrejet and Lockheed F-94C fighters. Similar units are being built for the U.S. Navy's FJ-2 Fury and the Chance Vought F7U Cutlass. Others include Convair's big R3Y turboprop flying boat and an unidentified fighter.

With the exception of the Cutlass, for which Hamilton Standard is supplying the entire air-conditioning system, the Hamilton Standard units are confined to the function of supplying cooling air to the aircraft cockpits. Already flying with the Hamilton Standard unit in operation are the F-86D and the F-94C.

CHANCE VOUGHT F7U-3 MAKES INITIAL FLIGHT -- The first flight of Chance Vought Aircraft's F7U-3 Cutlass took place late in December from Hensley Field, adjoining the Chance Vought plant in Dallas, Texas, according to an announcement made by the U.S. Navy. The aircraft was designed to outfly or out-fight any other carrier-based fighter airplane in the world.

The twin-jet F7U-3 promises to be an even more formidable, better-equipped and harder-hitting weapon for the Navy's carrier-borne arsenal than its predecessor, the F7U-1, first sweptback-wing, tailless fighter to operate from a carrier.

The advanced version of the Cutlass, is larger, but similar in external appearance to the original F7U-1. It was built to give the U.S. Fleet a fast shipboard fighter with superior high altitude performance, greater range, greater rate of climb, exceptional maneuverability and the firepower to deliver deadly blows in combat.

NEW VERSION OF CHANCE VOUGHT CORSAIR -- Only a week after the first flight of the F7U-3, the new Chance Vought AU-1 Corsair also successfully completed its initial flight. Designed as an answer to the close ground support problems encountered in Korea, this latest version of the famous Corsair is heavily armed and at the same time equipped with heavy armor plate to protect the pilot from ground fire. It has been ordered in substantial quantities by the United States Navy.

The Corsair is the only propeller-driven fighter-type aircraft still in production in the United States. Since the first F4U Corsair was flown, more than 12,000 of the craft have been produced -- from the F4U-1 through the F4U-4 and F4U-5. The F4U-5 Corsair was also modified as a photographic and night fighting airplane.

U.S. COAST GUARD NOW HAS TEN-PLACE SIKORSKY HELICOPTERS -- The United States Coast Guard recently acquired an undisclosed number of 10-place H04S Sikorsky helicopters which it will use at a number of important points of operation, it was announced recently by Sikorsky Aircraft.

Ever since 1943, the Coast Guard has pioneered in the use of helicopters for search, rescue and other missions. With the continuing improvement in helicopter performance provided by Sikorsky, this versatile type of craft has become indispensable to the Coast Guard.

Aside from rescue work, the Coast Guard uses Sikorsky helicopters in such vital routine duties as security checks of ships and anchorages... checking harbor waters for oil pollution... inspection of navigation aids... harbor surveys and numerous other missions, all performed with greater efficiency by helicopter than by any other means.

UNITED AIRCRAFT EXPORT CORPORATION
EAST HARTFORD 8, CONNECTICUT, U.S.A.
European Office : 3/5 Warwick House Street, London, S.W.I. England

RESCUE AT 600 MPH

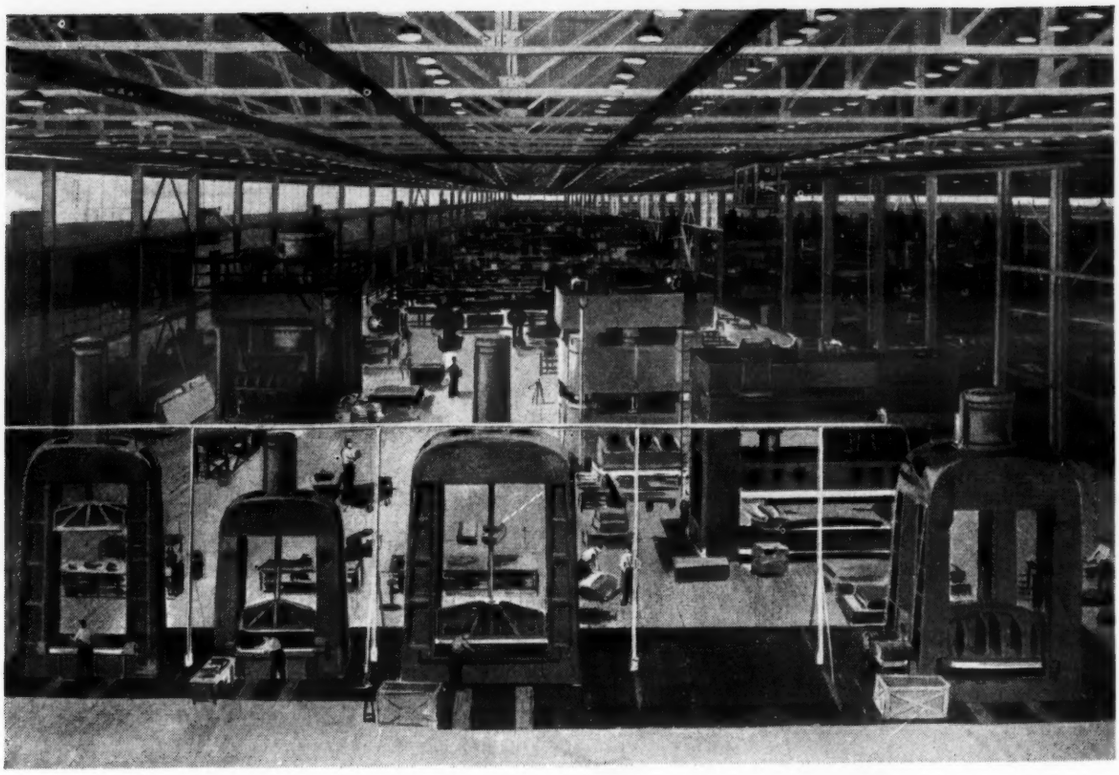
Through years of research, experimentation, and testing, the Pioneer Parachute Company has kept pace with the arduous necessities of super-speed jet aviation. Life-saving parachutes have been constructed, so strong, so shock-resistant, that they can withstand the most terrific tensions imposed upon them. Today's airmen can pilot their swift craft with perfect faith that the parachute they wear will carry them from danger to safety with precise, automatic, fool-proof dependability. As man seeks new horizons of speed in flight, Pioneer will make his continued safety their proud goal of achievement.

When trouble comes, the pilot pulls a trigger; the rest happens automatically. Ejection seat and pilot are shot clear of the plane; the small drogue chute attached to the seat stabilizes and slows down the speed of the seat and pilot. The pilot then releases himself from the seat, pulls the rip-cord which opens his parachute, and descends safely to earth.

PIONEER PARACHUTE COMPANY, INC.
MANCHESTER, CONNECTICUT, U. S. A.

PARACHUTES MAKE THE DIFFERENCE!

Switzerland : RIWOSA S.A. — Witikonerstrasse 80 — Zurich 32, Switzerland
Holland and Denmark : Schreiner & Company — 24 Javastraat — Den Haag, Holland
France : M. Guy Robert — Equipements d'Avions & d'Aérodromes — 11 Rue Tronchet — Paris 8, France
Turkey : Mr. Affan Ataceri — 69 Adakale Sokak — Yenisehir, Ankara, Turkey
Belgium : Benelair, Ltd. — Rue de la Loi 114 — Brussels, Belgium
Sweden and Finland : Mr. Ake Forsmark — Kummelvagen 9 — Alsten — Stockholm, Sweden
Norway : Wideroe's Flyveselskat A.S. — Kr. Augustsgt. 19 — Oslo, Norway



WHAT Area DOES CANADAIR COVER?

Equal in size to a vast building 350 feet wide and over 5,000 feet long, the 42 acres of covered factory space . . . with 70 acres for expansion . . . combine with the adjoining airfield to make Canadair an important factor in world aircraft production.

Production-minded visitors from all parts of the world constantly remark on the up-to-the-minute equipment that fills bay after bay in this efficient Canadian plant . . . and in its great spaciousness they see one of the many reasons for smooth rolling, high productive capacity.

With acre after acre of some of the finest aircraft manufacturing capacity . . . Canadair, now turning out a variety of military aircraft, is capable of producing all types of aircraft from design to completion.

For further information: European Representative, J. H. Davis, Princes House, 190 Piccadilly, London, W1, England.

Vignettes of CANADA — AIR LAND

An example of the alertness of Canada's air-mindedness is this recent flight against time . . . On January 14th, 1952, a dime-sized piece of radio-active metal was taken out of the Chalk River atomic reactor in the Province of Ontario and whipped away by a Trans Canada Airlines plane to the University of Michigan laboratories in the United States. Since the radioactivity in the radio-isotope of palladium dies very quickly . . . speed was of the essence. This incident is typical of the way Canadians turn to the use of aircraft for unusual and difficult undertakings.

Canadair
LIMITED, MONTREAL, CANADA

Alfa Romeo

WINS
THOUSAND MILE AIR RACE

BARI - SEPTEMBER 23rd, 1951

Sports class

1st Guido FERRARI

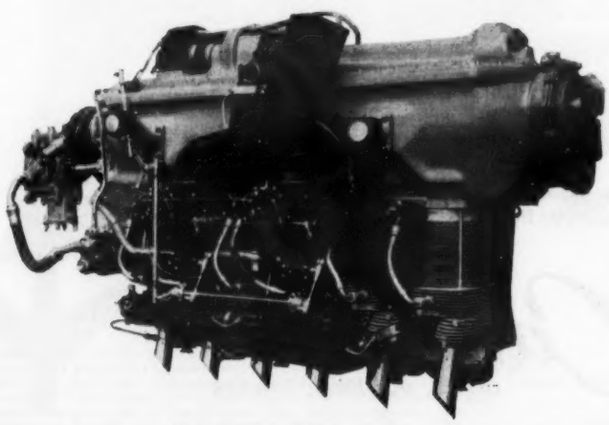
Ambrosini S.7 - Alfa Romeo 115 ter engine, which covered 1700 km in 5 hrs. 8 mins. 7 1/5 secs. at an average speed of 329,096 km/h

2nd TOMMASINI - Ambrosini S.7 - Alfa R. 115 ter.
3rd CASANOVA - Ambrosini S.7 - Alfa R. 115 ter.
4th DE BERNARDI - Ambrosini S.7 - Alfa R. 115 ter.
5th LONGANO - Ambrosini S.7 - Alfa R. 115 ter.
6th CAPONETTI - Ambrosini S.7 - Alfa R. 115 ter.
7th DI DONNA - Ambrosini S.7 - Alfa R. 115 ter.
8th SALAMINA - Ambrosini S.7 - Alfa R. 115 ter.
9th ANDALO - Ambrosini S.7 - Alfa R. 115 ter.
10th DOMENICI - Ambrosini S.7 - Alfa R. 115 ter.
11th PADOVANI - Fiat G.46 - Alfa R. 115 ter.
12th LANCIA - Ambrosini S.7 - Alfa R. 115 ter.

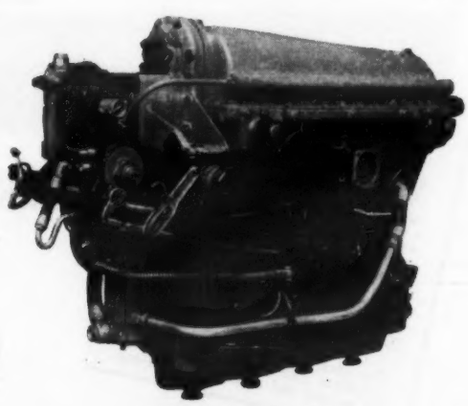
Touring class

1st Vico ROSASPINA

Ambrosini "Grifo" - Alfa Romeo 110 engine, which covered 1700 km in 8 hrs. 49 mins. 9 1/5 secs. at an average speed of 191,626 km/h.



Alfa Romeo 115 ter engine

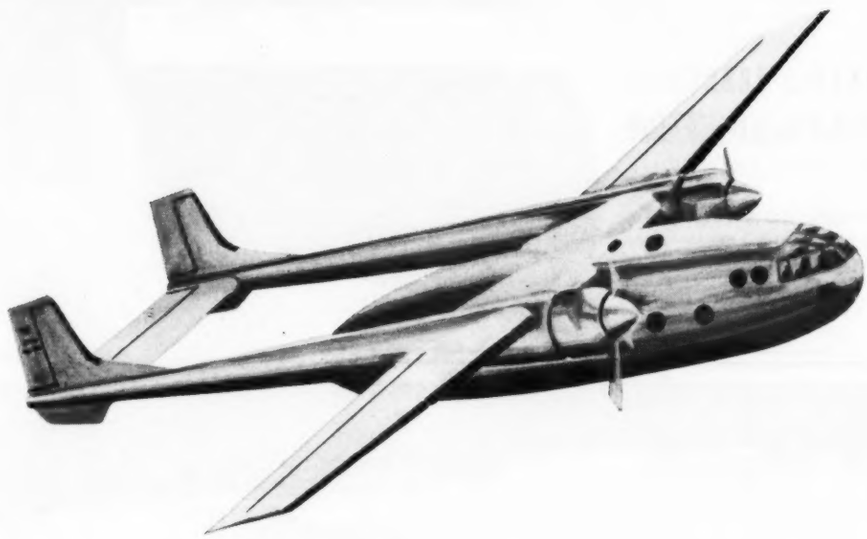


Alfa Romeo 110 engine

AVION CARGO

NORD 2501

11,685 lbs
commercial load



Ordered in quantity

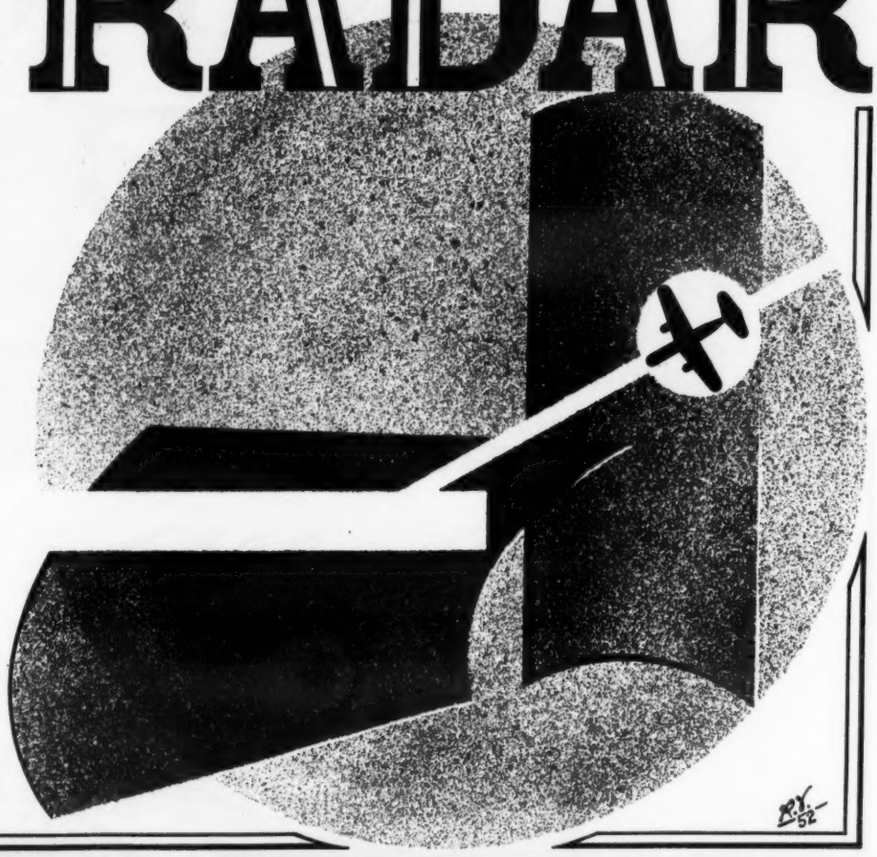
Range 1550 miles
Cruising speed 210 m. p. h.

SNCAN 20, rue Vernier PARIS 17e GALvani 94-52

H. M.

For all types and uses of

RADAR



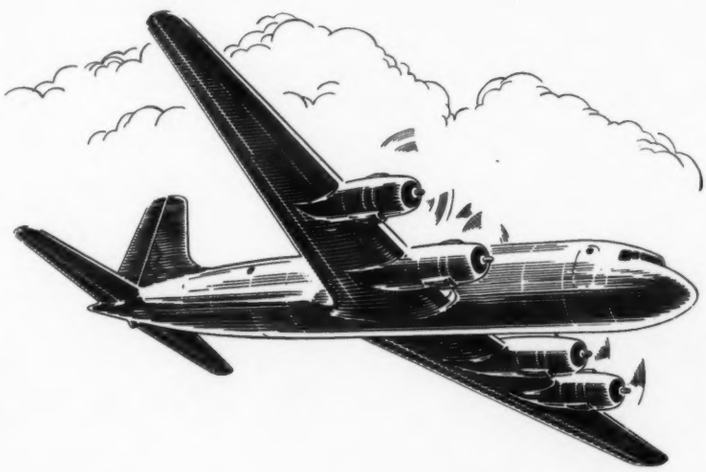
CFTH

COMPAGNIE FRANÇAISE
THOMSON-HOUSTON
GROUPE ÉLECTRONIQUE

DIRECTION COMMERCIALE
4, RUE DU FOSSÉ-BLANC - GENNEVILLIERS
SEINE - FRANCE GRÉSILLONS 33-05

SOCIÉTÉ NATIONALE D'ÉTUDE ET DE CONSTRUCTION DE MOTEURS D'AVIATION
150, Boulevard Haussmann - Paris 8e

He's a world famous musician



...he always flies Douglas DC-6

FLY DOUGLAS DC-6

on these leading airlines of the world

AA *Argentine* - **AMERICAN** *U.S.*
BCPA *Australian New Zeeland* - **BRANIFF** *U.S.* - **CMA** *Mexican*
***CONTINENTAL** *U.S.* - ***CPAL** *Canadian* - **DELTA** *U.S.*
* + **FLYING TIGER** *U.S.* - **KLM** *Netherlands* - **LAI** *Italian*
NATIONAL *U.S.* - **PAL** *Philippine*
PANAGRA *U.S.* - ***PAN AMERICAN** *U.S.* - **SABENA** *Belgian*
SAS *Danish Norwegian Swedish* - + **SLICK** *U.S.*
SWISSAIR *Swiss* - ***TAI** *French* - **UNITED** *U.S.*
***WESTERN** *U.S.*

**Soon* + *Air Freight*

Many of these and other world airlines also fly dependable Douglas DC-3s and DC-4s.

Twice as many people fly

DOUGLAS

as all other airplanes combined

AERONAUTICA MACCHI

VARESE (ITALY)

AER MACCHI

FIGHTERS

M. B. 324
Single-seater jet

D.H. 100 "VAMPIRE"
Single-seater jet
DE HAVILLAND licence

TRAINERS

M. 416
Side-by-side two-seater - Primary trainer
FOKKER S. 11 licence - LYCOMING engine

M. B. 323
Two-seater in tandem
Basic trainer

PRIVATE AND EXECUTIVE AIRCRAFT

M. B. 320
Twin-engined six-seater
(CONTINENTAL E. 225 engines)
Range 1620 km
Consumption 20 litres per 100 km

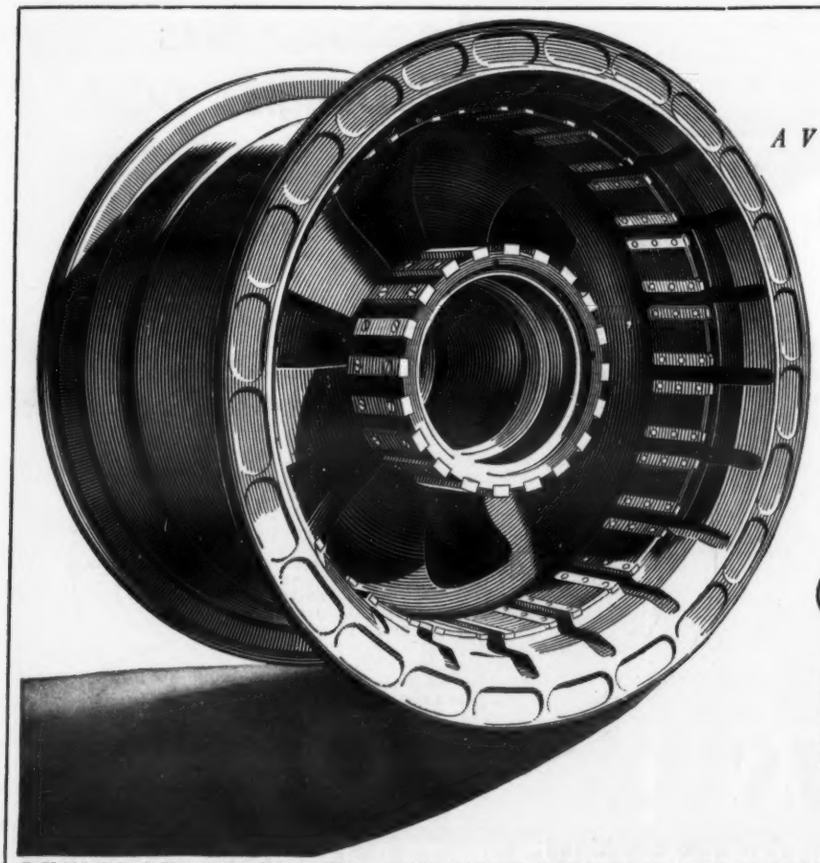
M. B. 308
Side-by-side two-seater
(CONTINENTAL C. 85/C. 90 engine)
Range 800 km
Consumption 10 litres per 100 km

M. B. 308
Side-by-side two-seater seaplane
(CONTINENTAL C. 90 engine)
Range 600 km
Consumption 10 litres per 100 km

Sales organization :

SOCIETÀ COMMERCIALE AERONAUTICA MACCHI

Corso Vitt. Emmanuele 31 — MILAN — (Tel. 700.402)



AVIATION EQUIPMENT

BY **DUNLOP**

WHEELS

Dunlop wheels are of cast construction in magnesium alloy for land based aircraft and a special aluminium alloy for amphibian services. Main wheels are designed to form a single unit with their brake assemblies. They are the product of one of the largest wheel factories in the world.

DUNLOP RUBBER CO. LTD., (AVIATION DIVISION) FOLESHILL, COVENTRY - Depots throughout the World

ON THE PRINCIPAL ROUTES OF
AIR FRANCE
you will travel by "CONSTELLATION"

"the Atlantic favorite"

To all seasoned air travellers the name "Constellation" has come to symbolize reliability, speed and comfort.

For several years Air France's every effort has been directed towards offering all its passengers on long-distance services the privilege of travelling by this wonderful aircraft.

Today Air France is proud to be able to announce that this result has been achieved on all its major international services.

You can go by Constellation

To South America : Recife, Rio, Buenos Aires. To Africa : Dakar, Konakry, Duala and to Madagascar. To the principal cities of Europe and the Near and Far East. Finally between Paris and New York you can enjoy the added comfort of a sky lounge chair.

AIR FRANCE

ALL TRAVEL AGENCIES AND 119 CHAMPS-ÉLYSÉES - BALZAC 70-50 - 2 RUE SCRIBE - OPÉRA 41-00

These figures speak for themselves :
In 1947 : 423,115 passengers
In 1950 : 774,906 passengers
In 1951 : 1,000,000 passengers

ADVANCED TRAINER...

FOR THE FIRST GUIDED MISSILES GROUP, U.S. ARMY

The United States Army Field Forces today is training its first Guided Missiles Group with Fairchild Missiles. In firing these advanced type anti-aircraft missiles, the Army Field Forces is preparing now for the day when missile batteries will defend cities and vital military installations.

Firing on the desert missile range at Ft. Bliss, Texas, officers and enlisted cadres are learning the skills and techniques necessary for the tactical application of these new weapons under conditions similar to those in actual combat.

Fairchild's Guided Missiles Division also is providing similar anti-aircraft missiles for the United States Navy and the United States Air Force. Its advanced engineering and technical facilities are being devoted to the design and development of new missiles and improved versions of current missiles to provide our Armed Forces with the latest and best possible weapons.

The Fairchild Plant at Wyandanch, L. I.—The World's First Privately Built Missile Plant

ENGINE AND AIRPLANE CORPORATION

FAIRCHILD *Guided Missiles Division*

WYANDANCH, N.Y.

Fairchild Aircraft Division, Hagerstown, Maryland • **Fairchild Engine and Stratos Divisions,** Farmingdale, Long Island, New York

Bomber Parade

Many people have had direct experience of it, and others have read more or less vivid descriptions. The bomber has become the scourge of the twentieth century. And since the invention of the atom bomb everyone has seen in it the Sword of Damocles of our age.

The present issue contains a comparative review of the bombers of the nations capable of making war. Then an attempt is made to investigate the problems of bomber strategy, with contributions from an internationally known Staff officer and a no less eminent research scientist. The former comes to the conclusion that the jet bomber has confounded the traditional reasoning of the strategists and is destined to become, in the form of the light tactical bomber, the weapon of the smaller powers. The other considers the bomber to be the "rich man's" weapon. It will ultimately develop into an unchallengeable weapon of attack and thus perhaps put an end to war.

This is by no means a piece of wishful thinking that the bomber will disappear. It doubtless will not disappear, but will continue to develop. But both writers help to dispel the fear of the bomber by replacing it with objective knowledge.

This concerns us all ! Anyone who has time to read in his daily paper about arms and armament expenditure, anyone who works actively on these armaments or who merely plays the passive part of the taxpayer, has the right and duty to be informed on the weapon of the century.

To help towards this end is the object of our "Bomber Parade."

THE EDITORS

The Jet Bomber Confounds the Air Strategists

and places the air offensive within reach of all

BY LIEUTENANT-COLONEL P. M. GALLOIS, PARIS

When they designed the B-47, Boeing's engineers knew that they were skipping a stage in the normal evolution of the bomber. But did they realize that their machine was to give a new meaning to the doctrine of aerial supremacy ? Did they know that with their slide rules and straight edges they were breaking idols that had been solidly carved out by the lessons of the last war ?

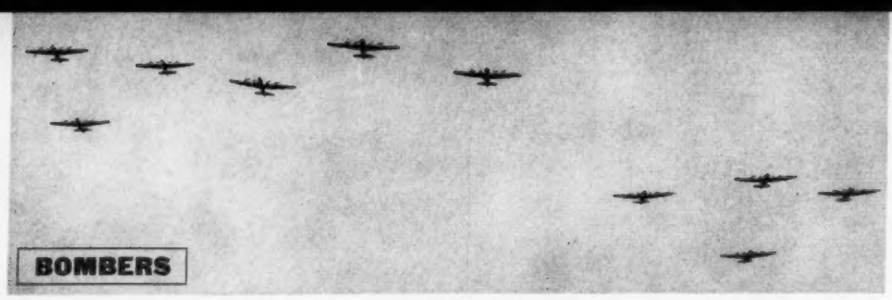
It is not the destruction of a few enemy aircraft or other air missiles or by occasionally warding off a heavy enemy attack that the victor wins supremacy in the air, writes Stefan Possony.* Paraphrasing Mahan, he continues, we can say that this is achieved by crushing air power, capable of wiping all enemy aircraft out of the sky. "Aerial supremacy is the ability to use the air space for offensive, defensive or airborne supply operations, while preventing the enemy from doing the same," writes Lord Tedder in more general and consequently more careful terms. According to Seversky, "aerial supremacy implies (1) the ability to attack at will the enemy's means of waging war, and (2) the ability to inflict greater air losses on the enemy than our own, if he attacks our own production resources." Although technical progress has not invalidated the first two terms of each of the two latter definitions, very little remains, on the other hand, of the two others, though this may perhaps be tem-

Phase I of the "classical" sequence of events leading to the conquest of mastery of the air is to destroy the enemy's defensive air power in the air or on the ground. In World War II all belligerents used these tactics : picture shows Russian fighters destroyed at their base early in the Russo-German war.

Another view illustrating the first phase in the conquest of aerial supremacy. German low-flying aircraft setting Russian fighters on fire at their base.

Phase II consists of sending formations of fighter-escorted bombers to attack the enemy's aircraft production potential. During the last war these daylight bombing sorties served the additional purpose of destroying the remnants of German and Japanese fighter strength. The Boeing B-17 bombers shown over Germany fly under fighter cover operating at greater height.

* "Strategic Air Power for Dynamic Security."



Phase III is the destruction of other enemy military resources by unescorted bombers, such as these Boeing B-50 "Superfortresses."

porary. Almost all the air strategists, and almost all the expert writers on aeronautical "doctrine," have up to now treated the conquest of aerial supremacy through destruction of the enemy in flight as an unalterable rule : a rule all the more firmly fixed in that it was founded on experience acquired during the latest hostilities. And the schools of air warfare, caught between the weight of a recent past and the abstractions of a future as yet barely sketched out by the calculations of the engineers and operational research offices, are forced to study the classic sequence of events in the conquest of aerial supremacy : first, battles between fighters and destruction in flight of the enemy's means of interception, then expeditions of escorted bombers to attack the enemy's aeronautical production, and finally, once the enemy is deprived of the means of protecting his skies and defending his territory, destruction of the other sources of his military power by groups of bombers, unescorted this time, until supremacy over the enemy is also achieved in the ground fighting.

In Korea, where jet aircraft designed since the end of World War II have met for the first time, it has been proved that combat between fighters does not pay. The communiqués report that 50 to 60 fighters on each side can engage in the most violent of battles with no other result than one or two "probables" and two or three machines "damaged." At this rate of destruction it is difficult to see how one of the belligerents can ever clear the other out of the skies. And it is equally difficult to see how the second, and even more so the third, phase of the classic sequence, that is, the entry into the lists of the expeditions of conventional bombers, at first escorted, then alone, can be opened.

During a press conference a few months ago, General Vandenberg stressed that whereas the U.S. Air Force had destroyed 13,600 Chinese and North Korean vehicles and 1430 railway trucks in three months, they could count no more than fifty enemy aircraft destroyed.

Unable to take them by surprise on their airfields behind the "bamboo curtain" beyond the Yalu river, General Ridgway's fighters had been obliged to restrict themselves to pure air battles, with very thin results.

The result of these actions is seen in this photo of Tokyo at the end of World War II. Boeing B-29 bombers flattened whole districts of the Japanese capital—without using the atom bomb.

Attacks on industrial targets were repeated more recently during the Korean war, although the Americans have never been able to gain the mastery of the air in that theatre, owing to the immunity of Communist air bases in Manchuria. The photo shows the ruins of the Chosen oil refinery at Wonsan.

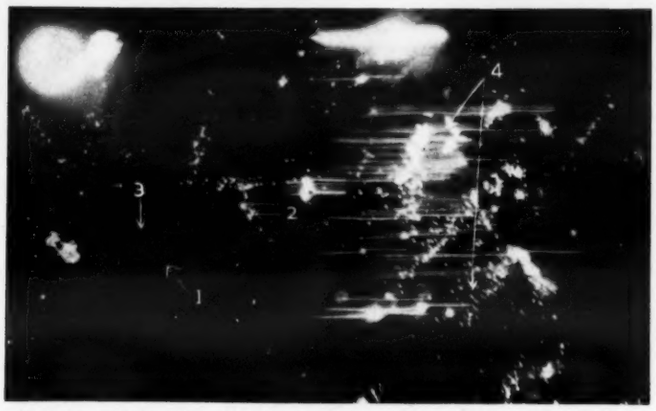
End of preliminary combats

Thus, since the armament of combat aircraft and their firing equipment has not evolved at the same rate as their major performance, since the physical difference between the man who pilots the machines of today and the man who used the cross-bow and the arquebus the day before yesterday and the "Spad" yesterday is slight, and since finally the tactics of the past are not compatible with the speeds of the present, the traditional method of conquest of aerial supremacy has been deprived of its usual preliminary combats.

The second phase, in which bombers are opposed by fighters, would be no more successful if the fighter were a MiG-15 or a F-86 "Sabre" and the bomber a Boeing B-47. The first two aircraft are given as having a Mach number between 1 and 1.15. The third could fly at 90 or even 95 % of sonic speed. To detect the bomber, get the fighter into position—even by radar—take aim and fire, a difference in speed of one or even two tenths Mach is no longer sufficient.

At present, with the existence side-by-side of aircraft such as the F-86 and its immediate derivatives on the one hand, and the B-47 on the other, it would seem that "aerial supremacy" will be obtained less through the sum of the losses inflicted on the enemy in flight and on the ground, as in the tactics successfully employed only six or seven years ago, than by pinning his air forces to the ground. It is thus easy to understand the importance of the "Manchurian sanctuary" in the operations in Korea and the "Chinese sanctuary" in those in Indo-China, if the latter, rising in the hier-

Unescorted bombing raids on German production centres were carried out in the last war chiefly by the RAF. The view above shows a "Lancaster" bomber as seen from a sister aircraft, silhouetted against A. A. artillery bursts.



Bombing target as seen from a British bomber : Hamburg during a night raid.

archy of wars, should one day take on the same character as the former.

Better still, the near-sonic offensive formations, reaching speeds close to those of the defence and thus being able to operate without the enemy's fighter force first being neutralized, will achieve a new form of aerial supremacy by the simple fact that they can move with impunity in enemy skies. If the enemy has similar offensive forces, he can of course obtain the same advantage. In short, since the means of denying a vast portion of space to jet bombers are lacking today, the old definition of aerial supremacy is no longer valid, and each of the belligerents, provided he can put a near-sonic offensive formation into the air, can have the privileges which of old were won only by a long and hard battle. And whereas, in the past, the superiority of one air force over another was the fruit of the efforts of research offices and, among other factors, of the skill of the crews in using in combat the machines supplied to them, today design and engineering are even more decisive, and it is really on the drawing board, in the wind tunnel and the factory that—if not "aerial supremacy" as it was understood yesterday—the "ability to go and destroy the enemy's defence potential with impunity" is won.

Combined range-aerodrome "manoeuvres"

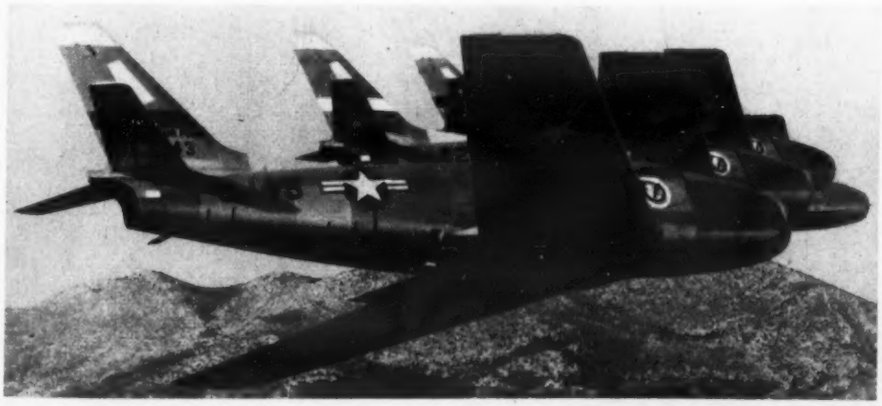
Another result of the appearance of the B-47 and its British and Soviet contemporaries, is the fact that "manoeuvring of ground organization" becomes of even greater importance than manoeuvring in flight. If in present-day conditions air combat does not pay, the ground organization required for jet equipment is so cumbersome that the latter's invulnerability in the air is balanced by its vulnerability on the ground. Once the jet bomber's nose has been poked into sonic turbulence, once the engineers are protected by its speed and secure in their knowledge that it is beyond the reach of conventionally armed fighters, they will seek to push back the wall of distance in the same way as the have done the wall of sound.

Of two light or medium jet bombers, the one with greater range will be able to place its departure base out of reach of the other. Then it will be not only invulnerable in flight, but also secure on the ground. So much so that, assuming that regular and rapid increases in propulsion power continue logically—at least up to a certain limit, where jet engines are concerned—it will not only be tomorrow's commercial aviation that will be vitally interested in efforts to reduce consumption. Low consumption gives the victor the greatest possible "extension" and removes his bases from the reach of an enemy technically less well equipped.

Finally, if the light interceptor, designed for the defence of vulnerable points, could leave its undercarriage behind on the ground and take off from a trolley, catapult or rail, the light jet bomber—or rather the medium tactical aircraft, to adopt a more general designation in view of the nature of the projectiles dropped—would also gain by using similar devices to escape from the trap formed by the classic aerodrome with long concrete runways. Thus the "ground organization manoeuvre" which replaces manoeuvres in flight, is founded both on range and on the effort to render departure and return bases invulnerable.

To sum up, four years of cold war have been sufficient to invalidate the experience gained in four years of hot war. Between 1947, the year of the B-47's first flight, and the beginning of 1951, the methods of employing the air arm have been completely overturned by the application of jet-propulsion to bombers and, in a more general sense, to offensive forces. The classic process by which supremacy in the air was won as late as yesterday is today completely useless. Defence and attack both have weapons with closely similar performance, so

Fast jet fighters like the North American F-86 "Sabre" often tangle with the equally fast Russian-built MiG-15s, but even in dog fights involving 100-120 aircraft casualties are low. After the engagement the MiGs retire behind the "Bamboo Curtain" beyond the Yalu River.



Tactics of nailing the enemy's forces to the ground are used in the Korean war wherever possible. They were previously employed during World War II, as is illustrated by these German bombs falling on a Soviet airfield.

Boeing B-29 bombers in Korea have been used for both strategic and tactical bombing missions.

that when the technical limitations of the equipment, the psychological limitations of the crews are balanced out as well as may be, all the traditional advantages remain with the side that succeeds in grasping the initiative.

The jet bomber needs no compromise

From the technical point of view the design of the jet bomber, at any rate today, is a combination of a number of different but compatible requirements, whereas the present-day fighter is a compromise between completely contradictory qualities. In order to climb high the fighter must have great power, be of refined design and have a relatively low wing loading. Yet the combat manoeuvrability demanded of it is incompatible with the high aspect ratios which contribute towards the fineness of a design, while speed, the cardinal virtue of any such machine, does not permit of excessively low wing loading. The fighter must be able to fight at all altitudes, so that here again it is at a disadvantage compared with the bomber, which chooses its route and may have been designed to operate in a clearly defined region of space. As regards armament and equipment the fighter's limitations are even more obvious. It has to go and find its adversary, whereas the latter has only to keep watch for its approach. The former's radar has to operate in all directions, that of the latter need cover only the danger zone. Because of its size the fighter's armament, in a given direction of attack, will always be at most equal to that of the bomber, particularly since the latter represents a larger and more stable gun platform and since it can open fire from a greater distance and for a longer time. At very high altitude there is no common measure between the situation of a machine moving on an almost rectilinear course and that of an aircraft with a high wing loading having to manoeuvre in order to succeed in its task of interception. Near the limit Mach number the advantage is with the pursued, since the pursuer may be obliged to fire in the turbulent zone, which will increase the dispersion of present-day projectiles.

Is has been said that jet aircraft could seek refuge in sonic turbulence just as the bombers of years ago used to hide from fighters by diving into the clouds. Now that pursuers and pursued have neighbouring Mach numbers the comparison probably still holds good, and it is easy to understand that certain heavy jet machines require no rear armament.

Efforts have been made, by fitting power-boosting devices, to give the fighter the extra power needed to "force" the sonic barrier, or to give a temporary boost to climbing performance or in pursuit. In machines of 6 to 7 tons, where the fuselage is almost entirely taken up with power plant, armament and fuel tanks, the auxiliary plant is a handicap. The B-47's design on the other hand, has not suffered from the installation of its 18 ejection tubes for assisted take-off and speed bursts to escape pursuit. Nor have the lines of the B-36 been altered by the fact that it carries four supplementary jet units. Anyone who has seen bench tests of the new jet engines of 8,000 to 10,000 lbs. thrust (or even more with afterburning) can imagine the size of the fighter that will one day be fitted with them, if no other method of propulsion is found to take their place.

At the present stage of development, the jet bomber has several advantages over the jet fighter – longer range, virtually equal speed, great operating height, better gun platform. The three aircraft above are six-engined Boeing B-47 "Stratojets," the first medium jet bombers to go into squadron service.

Must the bomber have forward armament ?

It is obvious that the present superiority of the bomber over the fighter must not in its turn be taken as an unalterable fact. At some time in the future, either because the light interceptor itself regains its advantages, or because the air-to-air guided missile restores them to it, or even because it is replaced altogether by the ground-to-air guided missile, the relative advantages now held by bombers and fighters may be reversed again.

Outclassed when attacking from the rear, the conventional jet fighter may be forced to employ different tactics. If, for a time, its speed is of the same order as that of its adversary, it could be "vectored" from the ground not to the rear of the bomber but to the front, and could release its load of projectiles in a single attack, without attempting a second. One result of this might be to modify once more the bomber's defences, by making it necessary to have guns in front rather than in the rear.

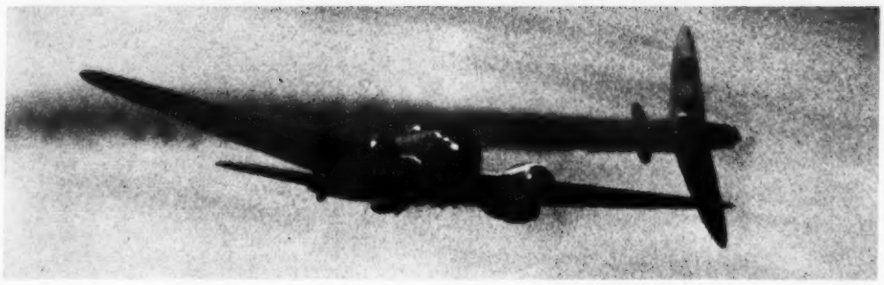
In addition, the increase in the jet bomber's performance is nowhere near coming to a full stop. Now that it has won the battle of speed and the very considerable one of range, it remains for it to improve its operational ceiling. It is likely that the Boeing B-47, when heavily loaded, cannot yet seek refuge in the upper tropopause. The Vickers-Armstrongs "Valiant" appears to be at once exploring the domain of speed and enlarging that of altitude. In this way the range of this type of machine would be naturally increased, since the aircraft would gain altitude as it lightens its load of fuel, and its consumption would diminish as it climbs.

The light bomber's trump card

But the most decisive factor, if not on the political level, at any rate on the military, is the combination of bomb and tactical aircraft rather than of strategic aircraft and atomic projectile.

The advantages possessed by medium and heavy bombers, such as the B-47 (of 80 tons) or the "Valiant," over the means of aerial defence, are also held by the ex-fighter-bomber and today by the light and medium tactical aircraft. It is difficult to see how an offensive sortie by Republic F-84Es could be hampered or held up, except perhaps by ground anti-aircraft forces. And above all how will the even more narrowly specialized interceptors of tomorrow be able to stop a force of aircraft flying at low level and at very similar speeds ? They too have "mastery of the air" by the simple fact that they take off and advance towards their targets without running great risks of being intercepted and destroyed in flight.

Up to the present their activity has been very limited. Machine gun and cannon and batteries of rocket projectiles have had a low destructive



Should bombers be equipped with forward firing defensive armament? During World War II most bombers were armed in that manner. The caption to this German war-time photo says that a "British 'Spitfire' fighter attempted to make a head-on attack on this Heinkel He 111 bomber. A hectic running fight ensued until the front gunner succeeded in setting the fighter on fire..."

The first light bomber to go into squadron service was the North American B-45 "Tornado." Only a small number were built, and these have since been convertes into photo-reconnaissance aircraft.

power, particularly in relation to the resources used. If indeed the extent of the damage caused by the atom bomb and its weight and volume have been sensibly reduced, the combination of the light aircraft and the "pocket" projectile may have important consequences.

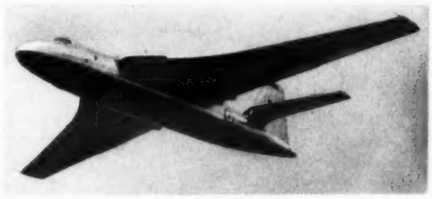
The "junior" bomb

We have insisted on earlier occasions in these columns on the special nature of the "A" bomb and have said that the more science succeeds in increasing its power the more serious will become any acts of hostility between the two blocks. The range of localized conflicts can be developed considerably, we said, without allowing any of them to become sufficiently serious to call forth retaliation by atomic bomb, the irremediable. And that in progressing from the A bomb to the A1, A2 and ultimately H bomb there was a risk of widening still further the scope for cold and nearly-cold wars.

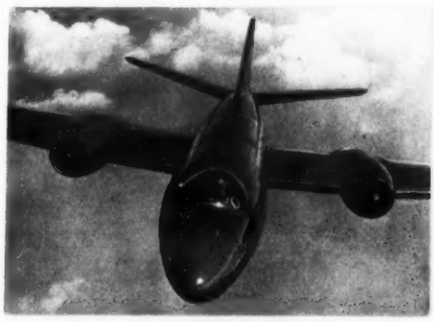
The pocket bomb, or "a" bomb, which is militarily so important because of its effect on the composition and cost of combat air forces, may also be of political significance. It is of ideal size for "small wars." It can remove the spectre of Hiroshima and Nagasaki and accustom humanity to the use of nuclear energy on the battlefield, even if only in a local conflict. Instead of the 20,000 tons of TNT to which the "A" bomb is equivalent, the "a" bomb would be equal to 50 to 100 tons, perhaps less. In the scale of destructive power it would take its place nearer to the "Grand Slam" than to "Gilda," and its use on enemy concentrations would not shake the whole structure of the present "modus vivendi." It would even have the advantage, this "a" bomb, of setting off a "chain reaction" and, by the progressive increase in their explosive power, of reducing atomic projectiles little by little to the rank of ordinary weapons.

It has been calculated that it took nearly a million bomber sorties to drop almost 3 million tons of chemical bombs on the Third Reich. Fourteen hundred "Halifaxes," "Lancasters," B-17s and B-24s, each loaded with an "A" bomb, could have obtained equivalent results as far as the extent of damage is concerned, and of course much greater results from the point of view of morale if the attacks were simultaneous.

Similarly, for tactical missions on the battlefield and in the immediate rear, the "a" bomb should be able to permit of a partial reduction in the flying equipment required. Strategic bomber fleets have everywhere been reduced to less than one tenth of their strengths of six or seven years ago. Light bomber and fighter-bomber squadrons could likewise be cut down, if only the destructive power of the projectiles used were multiplied by 30 or 50.

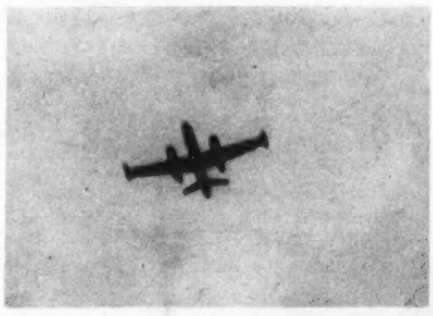


Another contender in the medium-weight jet bomber class is the four-engined Vickers-Armstrongs "Valiant," which has been ordered into production for the RAF.



Light jet bombers (like the English Electric "Canberra," above), refuelled in flight, and carrying small atomic bombs could become an effective weapon of war for nations not having the resources to build giant long-range bombers.

The Russians, too, have been paying attention to the light jet bomber. The twin-engined Tu-8 was one of the first, but has now been succeeded by large numbers of Tu-10s (above).



The "poor man's" offensive weapon

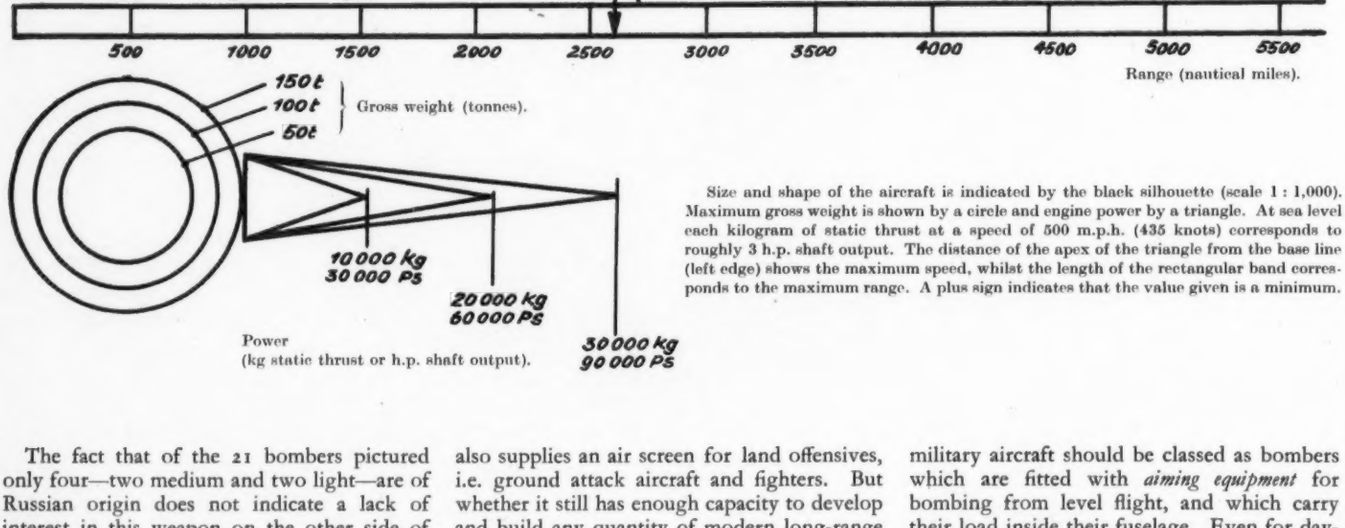
It remains then to provide an "extension" for the fighter-bomber and the light jet bomber. Since speed and range are still difficult to reconcile, particularly in the lighter machines, recourse will have to be had to refuelling in flight. The implications of the triple combination light bomber—"a" bomb—flight refuelling have doubtless not been lost sight of in the United States, where the problem of range has influenced all flying equipment programmes and decided many directions of development. But an interesting point, that should be particularly stressed, is that this combination of three would give singularly strong cards to the nations which are less well-off and have less powerful air forces. Provided they can acquire a supply of "a" projectiles, it would not be impossible for these air forces to provide the required aerial vehicle (a 12 to 15-ton jet aircraft for example), which, thanks to the power of its projectiles, would not need to be built in tremendous quantity. Thus, using nuclear energy and flight refuelling, these same air forces to which B-47 and "Valiant" are out of reach could still afford the equipment for powerful intervention at distance. And by an unexpected turn of events, it is just when economic and technical contingencies have constrained certain powers to axe some of their more costly and complex air force subdivisions that technical progress again may supply a short cut to air power thanks to the "miniaturization" of bombers and projectiles.

It is thus not exaggerated to say that in aviation affairs even the most obvious is incapable of resisting four years of progress. The doctrine of "aerial supremacy," in the form established by numberless signs and omens, has suffered considerably merely from recent increases in speed.

Know Your Bombers!

A Review

Boeing B-47



Size and shape of the aircraft is indicated by the black silhouette (scale 1 : 1,000). Maximum gross weight is shown by a circle and engine power by a triangle. At sea level each kilogram of static thrust at a speed of 500 m.p.h. (435 knots) corresponds to roughly 3 h.p. shaft output. The distance of the apex of the triangle from the base line (left edge) shows the maximum speed, whilst the length of the rectangular band corresponds to the maximum range. A plus sign indicates that the value given is a minimum.

The fact that of the 21 bombers pictured only four—two medium and two light—are of Russian origin does not indicate a lack of interest in this weapon on the other side of the Iron Curtain. Doubtless more bombers would be built there if the available industrial resources permitted. Tremendous efforts are being made to produce better bombers, as is shown by the project—or perhaps it is already a prototype?—of a Russian long-range bomber with swept wing and six propeller turbines (Tupolev Tu-75 ?) and a delta-wing bomber.

However, the heavy bomber will remain the weapon of the "rich" man. The strategy of the Soviet block (including China 750 million people) is of necessity based on offensive on land and defensive in the air. To support the infantry Soviet industry produces impressive quantities of tanks and artillery. In addition it also supplies an air screen for land offensives, i.e. ground attack aircraft and fighters. But whether it still has enough capacity to develop and build any quantity of modern long-range bombers (the Tu-4 is a copy of the now obsolescent B-29) is doubtful.

On the other hand the Americans (150 million people) appear to have decided in favour of the defensive on land and offensive in the air. Intercontinental bombers and atom bombs, both the products of a highly developed industry, are their trump cards. The British are following the same line, though on a smaller scale. The other European countries however are today at best equipped for a limited defensive.

What do we mean by bombers? The question is justified, since today every front-line aircraft—whether fighter, flying boat, naval aircraft—can carry bombs.—Only those military aircraft should be classed as bombers which are fitted with *aiming equipment* for bombing from level flight, and which carry their load inside their fuselage. Even for daylight raids with full visibility optical precision instruments for bomb aiming are indispensable. For raids from above the clouds or at night radar detection and aiming instruments must be provided.

Bombers attack either tactical targets in the theatre of operations (airfields, fortifications, communications, bridges) or strategic targets in the enemy's rear (particularly war plants such as steel works, refineries, power stations etc.). At any rate in theory. Whether this will really be so or whether once again in the event of war cultural and residential areas will be "rubbed out" and mothers, babies and old men murdered, is more than doubtful.

Number	MAKER AND TYPE	POWER PLANT			DIMENSIONS			WEIGHTS		PERFORMANCE		
		Maker and Type	Total thrust	Engine power	Span	Length	Wing area	Gross weight	Max. bomb load	Max. speed	Service ceiling	Max. range
			lbs.	h.p.	ft.in.	ft.in.	sq.ft.	lbs.	lbs.	knots	ft.	naut.m.
1	**Boeing XB-52 "Stratofortress"**	8 Pratt & Whitney J-57	appr. 80,000	—	—	—	—	approx. 350,000	—	540+	approx. 60,000	5,400+ [1]
2	**Convair B-36D "Conqueror"**	6 P&W "Wasp Major" 4 General Electric J-47	— 20,800	21,000 —	230'	162'	4,772	358,000	84,000	378	45,000	8,600 [1]
3	**Convair YB-60**	8 Pratt & Whitney J-57	appr. 80,000	—	—	—	—	approx. 350,000	—	540+	approx. 60,000	5,400+ [1]
4	**Boeing B-50D "Superfortress"** [2]	4 P&W "Wasp Major"	—	14,000	141' 3"	99'	1,769	173,000	28,000	350+	35,000+	5,200 [1]
5	**Boeing B-29 "Superfortress"**	4 Wright "Cyclone 18"	—	8,800	141' 3"	99'	1,769	135,000	20,000	325	35,000+	3,900
6	**Tupolev Tu-4**	4 Shvetsov ASh-90	—	8,700	approx. 141'	approx. 118'	—	—	—	approx. 325	approx. 35,000	approx. 3,800
7	**Boeing B-47 "Stratojet"**	6 General Electric J-47	31,200	—	116'	108'	—	185,000	20,000	approx. 540	40,000+	2,600+ [3]
8	**Vickers-Armstrongs 660 "Valiant"**	4 Rolls-Royce "Avon"	26,000	—	approx. 115'	approx. 115'	—	approx. 120,000	—	approx. 540	approx. 60,000	2,700+
9	**Short SA/4**	4 Rolls-Royce "Avon"	26,000	—	approx. 115'	—	—	—	—	485+	—	—
10	**North American B-45 "Tornado"**	4 General Electric J-47	20,800	—	89' 6"	74'	appr. 1,080	82,600	20,000	485+	40,000+	— [4]
11	**Ilyushin IL-16**	4 Chelomey M-003E	appr. 18,000	—	—	—	—	approx. 88,000	—	approx. 480	—	—
12	**Avro 694 "Lincoln 2"**	4 Rolls-Royce "Merlin"	—	7,040	120'	78' 3.5"	1,421	82,000	22,000	255	22,000	3,080
13	**Martin XB-51**	3 General Electric J-47	15,600	—	approx. 55'	approx. 80'	—	approx. 80,000	12,000	approx. 510	—	—
14	**North American AJ-1 "Savage"**	2 P&W "Double Wasp" 1 Allison J-33	— 4,600	4,800 —	71'	64'	—	55,000	—	430	40,000+	2,600
15	**North American XA2J-1**	2 Allison T-40	—	11,000	approx. 70'	approx. 70'	—	approx. 55,000	10,000	approx. 400	—	—
16	**English Electric "Canberra"**	2 Rolls-Royce "Avon"	13,000	—	64'	65' 9"	960	—	—	approx. 510	—	—
17	**SNCA du Sud-Ouest SO 4000**	2 Hispano "Nene"	10,000	—	58' 7"	64' 9"	807	approx. 48,500	—	approx. 490	—	—
18	**Tupolev Tu-10** [5]	2 Chelomey "Nene"	appr. 10,000	—	—	—	—	—	—	approx. 490	—	—
19	**Tupolev Tu-2**	2 Shvetsov ASh-82	—	3,450	61'	45' 3"	—	28,200	5,000	300	36,000	1,350 [6]
20	**Saab B18B** [7]	2 SFA DB 605B	—	2,900	55' 9"	43' 7.5"	471	19,400	—	310	—	—
21	**Martin B-61 "Matador"**	1 Allison J-35 (?) [8]	5,200	—	—	approx. 30'	—	—	—	approx. 540	—	—

[1] Bomb load at maximum range in all cases 10,000 lbs. (an atom bomb).

[2] In view of its very long range the B-50D could also be classed as a "heavy bomber," but is always regarded as a "medium" bomber.

[3] For a range of 2600+nautical miles the B-47 has to carry supplementary tanks.

[4] The "tactical radius of action" of the B-45 is 1025+nautical miles with supplementary tanks, or 700+nautical miles without.

[5] The designation of the Russian twin-engined jet bomber is not yet confirmed. Versions with M-018 axial compressor power plant (thrust 7700 lbs.) probably have the designations IL-26 and Tu-12.

[6] Range with 3,300 lbs. bomb load.

[7] The Saab T18B version also carries a 57-mm cannon (Bofors) and rocket projectiles.

[8] Unmanned bomber with remote control; a rocket, jettisoned when burnt out, is used as take-off aid; launching equipment.

Since the same aircraft type can frequently perform both tactical and strategic tasks, the custom has grown up of classifying bombers solely according to their range, as follows :

Heavy bombers : Range over 5000 nautical miles ; strategic tasks only.

Medium bombers : Range 2500 to 5000 nautical miles ; strategic and tactical tasks.

Light bombers : Range under 2500 nautical miles ; primarily tactical tasks.

Similarly bomb load no longer determines an aircraft's class. In heavy bombers it will be at least 4.5 tons (roughly the weight of an A-bomb), but may be up to 39 tons (two super-heavy H.E. bombs) if range is reduced. All medium and the majority of the light bombers can also carry a bomb load of at least 4.5 tons. Aircraft that can carry less than 1.5 tons of bombs (e.g. the Russian Petliakov Pe-2 and the Argentine I.Ae.24 "Calquin") are not included in our review.

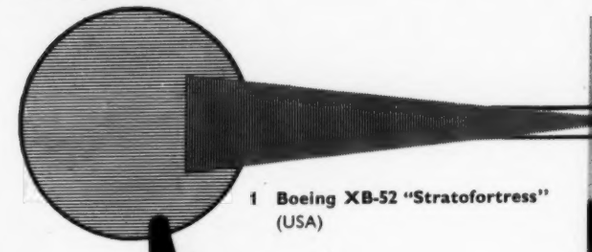
In the last war bombers were greatly inferior to fighters and could operate in daytime only when escorted. They therefore preferred to fly by night. Meanwhile—in spite of the general introduction of the jet fighter—the situation has changed. Even the Convair B-36 heavy bomber, which is still fitted with piston engines, and which fighter pilots swore they could shoot down under any operational conditions, has proved to be more powerful than its opponents. Since it flies in the lower stratosphere, at altitudes of attack of about 45,000 ft., and can reach a speed of over 380 knots with the aid of its four auxiliary jet engines, it is almost impossible to combat without a complete radar warning network and expert ground control of the fighters [1]. Since also a single atom bomb has the same destructive effect as roughly 2000 tons of explosive, a single A-bomber can be more dangerous than a whole formation of 200 fully-loaded four-engined bombers.

[1] So as not to exceed its maximum lift a heavily-loaded fighter may not turn in rarified atmosphere at high altitude with a load coefficient of more than 2 to 3. Even at a speed of only 485 m.p.h. this gives extreme radii of turn of 2 to 1.25 nautical miles. If the fighter is badly guided to its target and has to make a turn of 180 degrees, it takes 29 to 47 seconds for this. During this time the bomber has advanced up to 5 nautical miles, and can therefore be caught up only after another 20 nautical miles of pursuit.

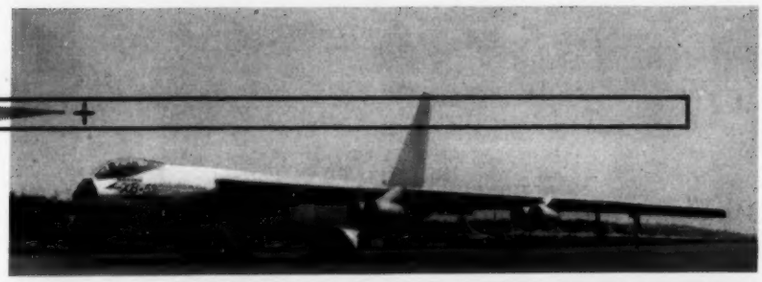
This however is not all. Bombers have learnt from the fighters and taken over their jet engines. Boeing, Convair and Vickers-Armstrongs' latest bombers almost reach sonic speeds at great altitudes. They can therefore be overtaken only by supersonic fighters or guided missiles. Both these types of defence weapons however are still only in the development stage. It also appears to have been possible, in spite of the jet engine's high consumption, to give the U.S. Air Force's heavy bombers, the Boeing XB-52 and Convair YB-60, astonishing ranges. They are now capable of reaching any point on the globe from their own bases (either in the United States or elsewhere) and returning to their point of departure.

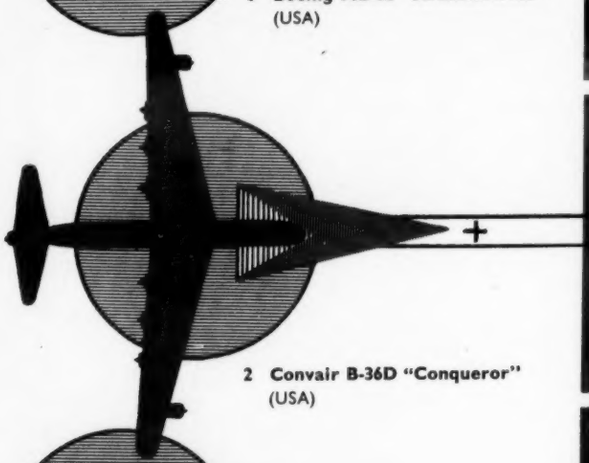
If bombers are today already at least equal to fighters, they will probably soon be definitely superior to them. On the one hand new wing forms are being tried out (delta bomber projects), on the other new power plants. It is to be expected that within a few years supersonic bombers with ramjet engines will be available, and will be followed shortly afterwards by supersonic rocket bombers.

Heavy Bombers

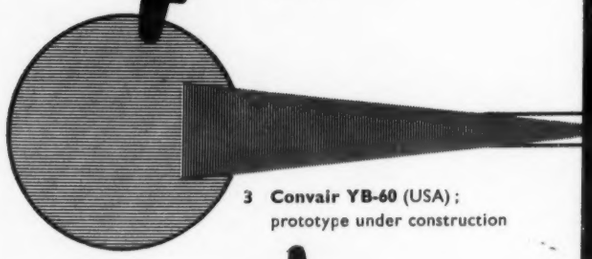


1 **Boeing XB-52 "Stratofortress"** (USA)

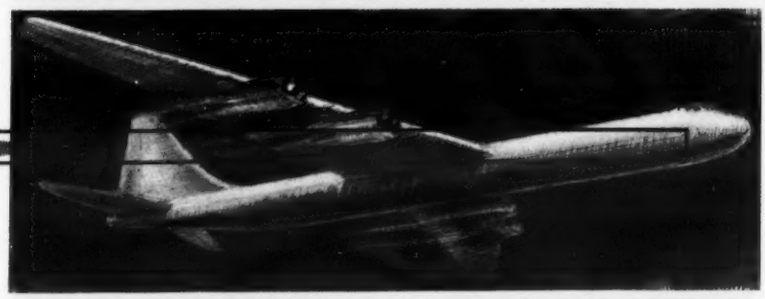




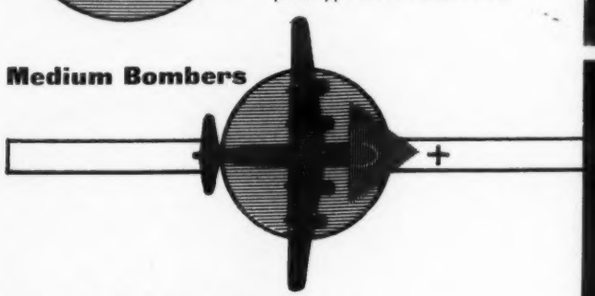
2 **Convair B-36D "Conqueror"** (USA)



3 **Convair YB-60** (USA); prototype under construction



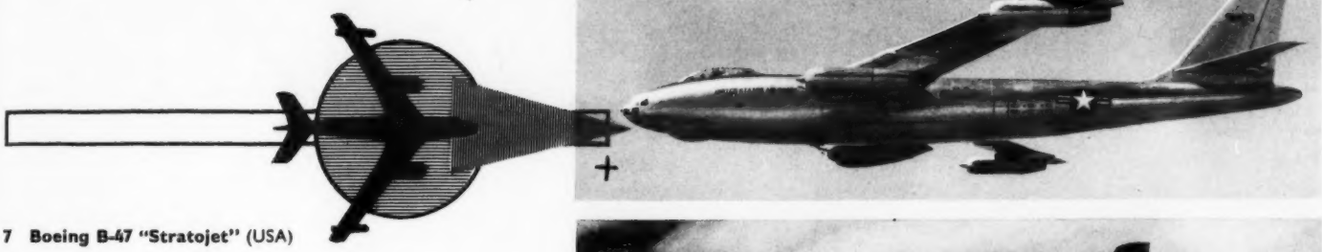
Medium Bombers



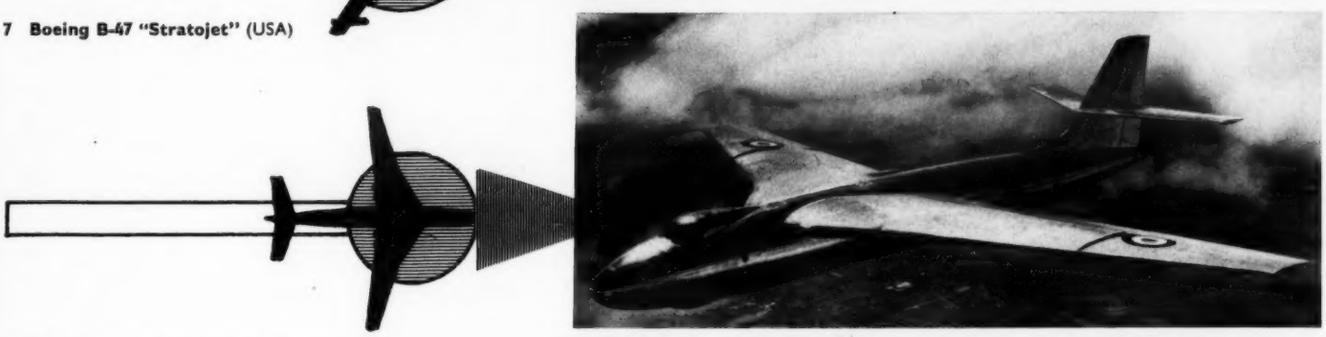
4 **Boeing B-50D "Superfortress"** (USA)

5 **Boeing B-29 "Superfortress"** (USA)

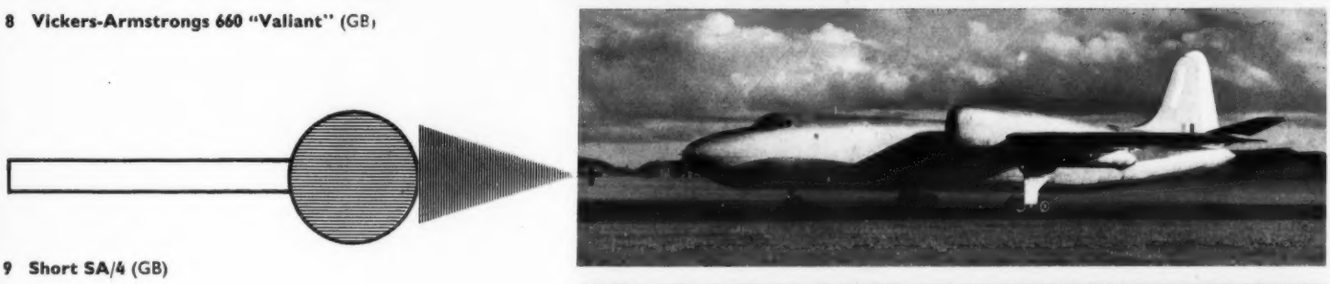
6 **Tupolev Tu-4** (Russia)



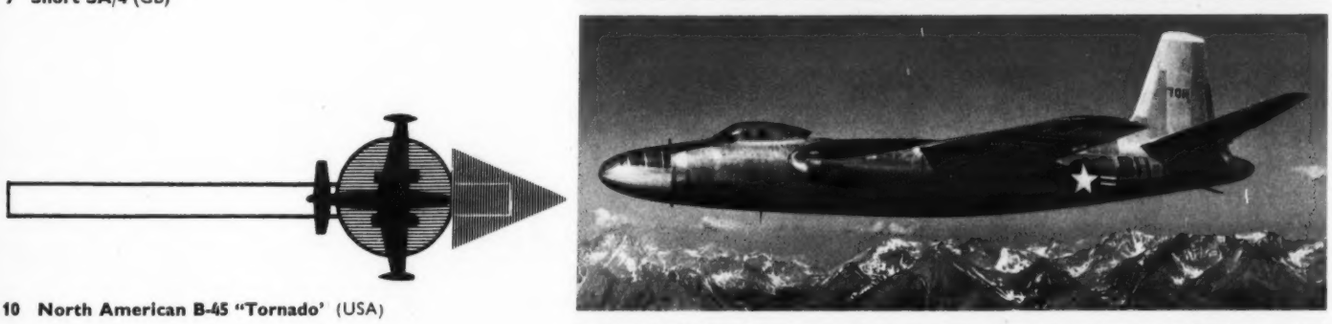
7 **Boeing B-47 "Stratojet"** (USA)



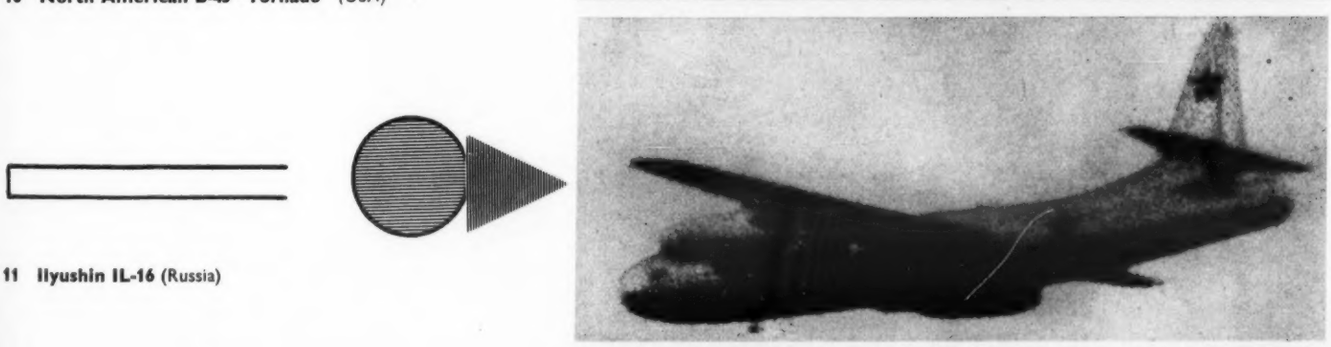
8 **Vickers-Armstrongs 660 "Valiant"** (GB)



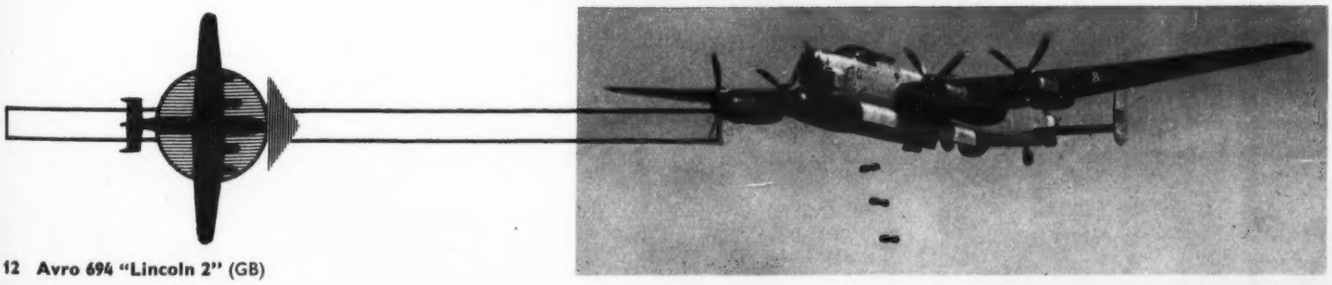
9 **Short SA/4** (GB)



10 **North American B-45 "Tornado'** (USA)

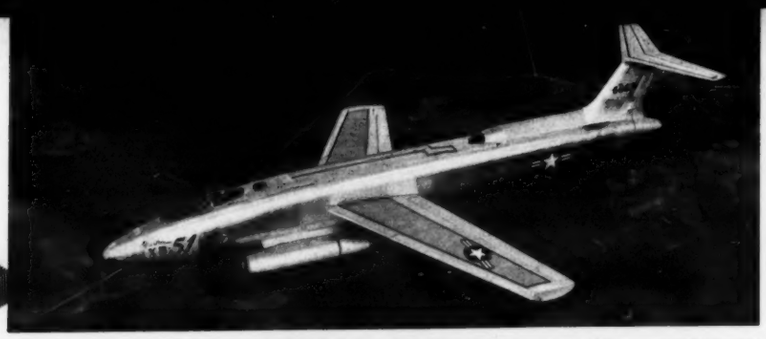


11 **Ilyushin IL-16** (Russia)

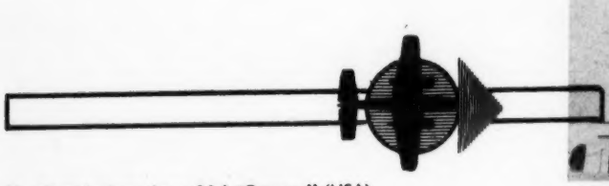


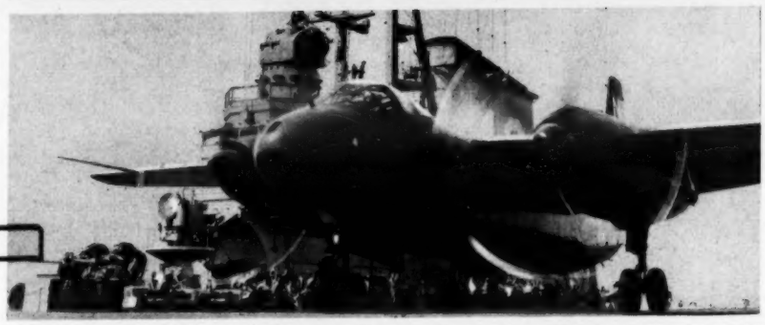
12 **Avro 694 "Lincoln 2"** (GB)

Light Bombers

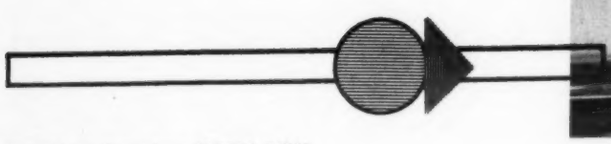


13 **Martin XB-51** (USA)

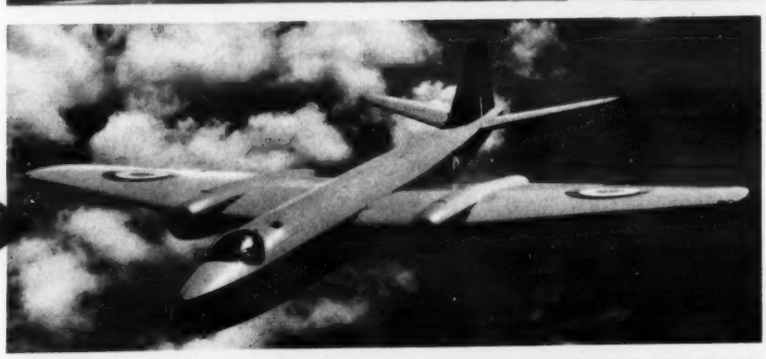




14 **North American AJ-1 "Savage"** (USA)

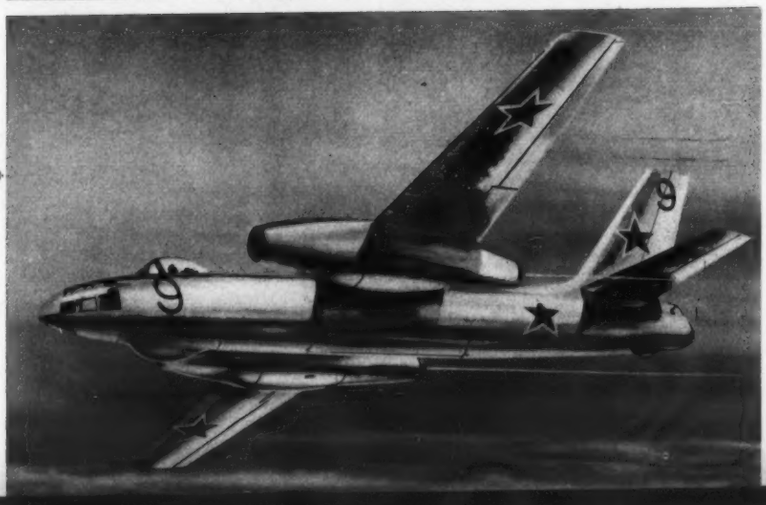


15 **North American XA2J-1** (USA)

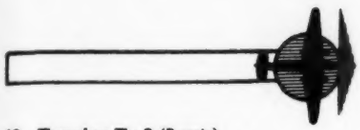


16 **English Electric "Canberra"** (GB)

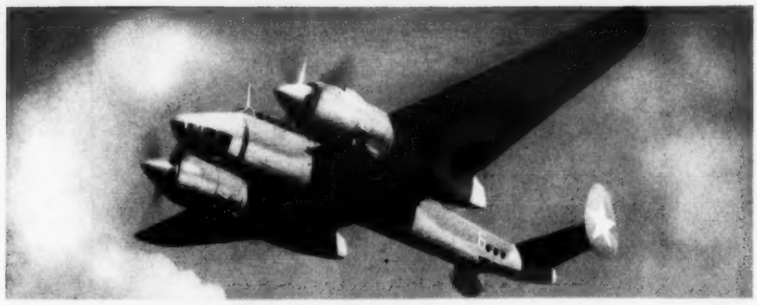
17 **SNCA du Sud-Ouest SO 4000** (France)



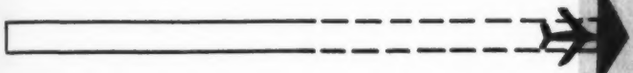
18 **Tupolev Tu-10** (Russia)



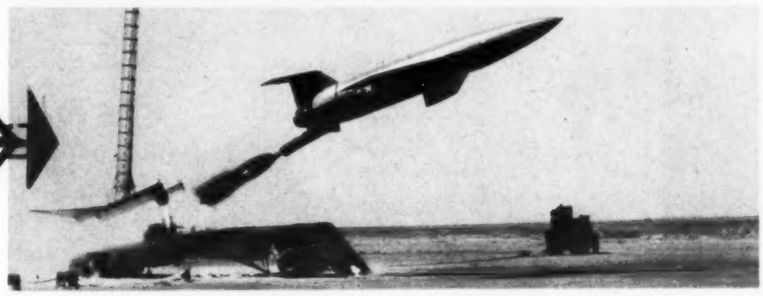
19 **Tupolev Tu-2** (Russia)



20 **Saab B18B** (Sweden)



21 **Martin B-61 "Matador"** (USA)



Chameleon Aircraft ?

It is almost exactly twenty years since the first and last League of Nations conference in Geneva "on the limitation of armaments" broke down, after vast expenditure of breath and paper. One of the main reasons for its failure was the fact that the experts could not agree on the definition of bombers and commercial aircraft. The ideal commercial aircraft was defined as one with long range, high speed and maximum payload. Unfortunately the same definition also applied to the best bomber. At that time Germany still had no air force, but she had built up a considerable civil air fleet, and was thus capable of becoming a threat to others. Our former colleague, the Frenchman Henri Bouché—who now represents his Government at ICAO Headquarters in Montreal—hit upon the very modern-sounding idea of "internationalizing civil aviation." To explain here why Bouché was unable to put his idea over at the Disarmament Conference would take too long.

On one point, however, there was no doubt. Commercial aircraft had actually been developed from bombers and vice versa. For example one of the first American twin-engined bombers, the Boeing Y1B-9A, became the first twin-engined commercial aircraft, the Boeing 247-D. Commercial aircraft were also derived from the French Lioré et Olivier twin-engined bomber and the four-engined Farman after World War I. The list could be extended *ad infinitum*.

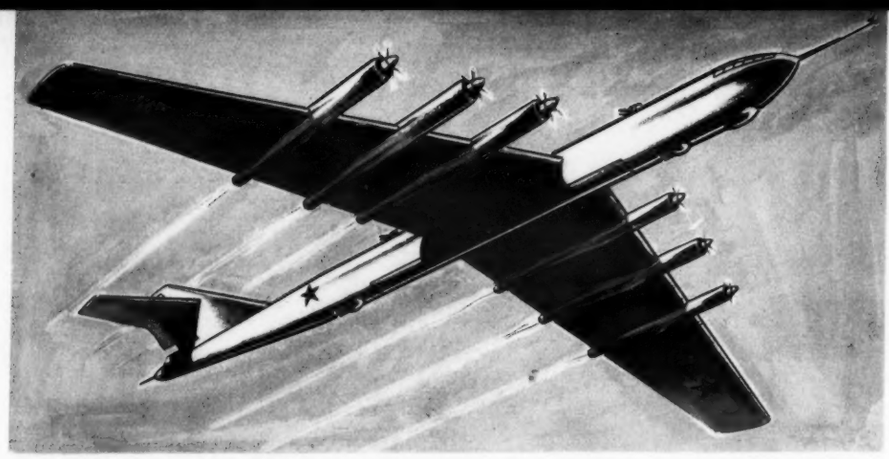
On the other side, it must be admitted that the Luftwaffe's first bombers were developed out of the Junkers Ju 52, Ju 86 and Heinkel He 111 commercial types, and that Mussolini's standard bomber at the outbreak of war, the Savoia Marchetti S 79, was known as the SM 75 in its civil version.

To take a more recent case : all the world knows that the much-praised four-engined "Stratocruiser" is neither more nor less than a commercial version of the Boeing B-29 "Superfortress."

However, it can be said, conservatively, that none of these "chameleon" aircraft have been ideal designs. The "Stratocruiser" gave Pan American Airways a lot of trouble for a long time, and the Junkers and Savoia bombers mentioned soon disappeared from the front line.

Only once has a conversion programme been at any rate a financial success, namely at the outbreak of World War II, when the Royal Air Force was short of bombers and Lockheed built hundreds of "Hudson" and "Ventura" reconnaissance bombers for it. These were military versions of the twin-engined commercial models, L 14 or "Lodestar." Nevertheless, Lockheed—and Douglas—has never attempted to mix military and civil designs in the design office. This may perhaps be the reason for the two firms' success in the commercial aircraft field.

Why has this question been raised ? Certainly not just for the sake of reminiscing . . . A short time ago the D.H.106 "Comet" jet airliner came on to the market, and it was immediately declared that it could be made into a very good bomber. Scarcely had the latest British bomber, the Vickers Armstrongs "Valiant," made its appearance than the experts were maintaining that here was the basis of the ideal future machine for British civil aviation.



Stalin's Global Bomber

First positive indication to the public in the Western democracies that Russia was not satisfied with her copies of the Boeing B-29, the Tu-4, was a statement by USAF General Hoyt S. Vandenberg. This was quoted in the *Saturday Evening Post* for 17th February 1951 and was as follows :

> "One thing we know for sure : The Soviet Union has been working intensively on a heavy bomber to match the Consolidated-Vultee B-36."

More recently, General Vandenberg has again credited the Russians with having bombers larger than the "B-29 copies" and capable of penetrating deep into U.S. territory from bases within the Soviet Union.

Since the first mention of this mysterious Russian bomber, there has been a sporadic appearance of odd facts about it. Some of these have been contradictory, but a number have been in agreement. It has been in each case reported as a swept-wing type with a high-set tailplane and powered by six propeller-turbines driving contra-rotating airscrews. A source which has previously proved reliable with "first" information about new Soviet aircraft designs has now produced sparse but convincing data.

The aeroplane has been generally reported as the Tu-75 or TuG-75, *credit* for design being given to Tupolev in the one case, and a partnership of Tupolev and Gurevitch in the other. Our information is that the engineer mainly responsible was a Dr. Ing. Baade, formerly with the Junkers Flugzeug- und Motorenwerke, who was transferred to Russia after the end of the war. In its proportions it is a logical blending of the features of the B-36 (itself a development of the B-29 specification) and the war-time Tupolev TB-7. In particular, the wing plan combines the relatively high aspect ratio, essential for good take-off and range performance, with the general taper proportions of the TB-7. Such a combination would be necessitated by strength considerations with the sweepback.

The tubular fuselage is the only logical one for a large bomber, since it minimises both drag and weight ; in any case, great fuselage volume is unnecessary, since both bomb and fuel loads are concentrated weights !

The pilot's station is "submerged" like that on the B-29 and there is a long probe, presumably carrying the usual yaw indicator of experimental types. This nose shape is the least certain part of the drawing and some reports suggest that it is rather more pointed than shown ; but there seems no reason for this.

The swept tail unit, with the stabiliser high and clear of the wing-wake, has the general proportions of the TB-7 again.

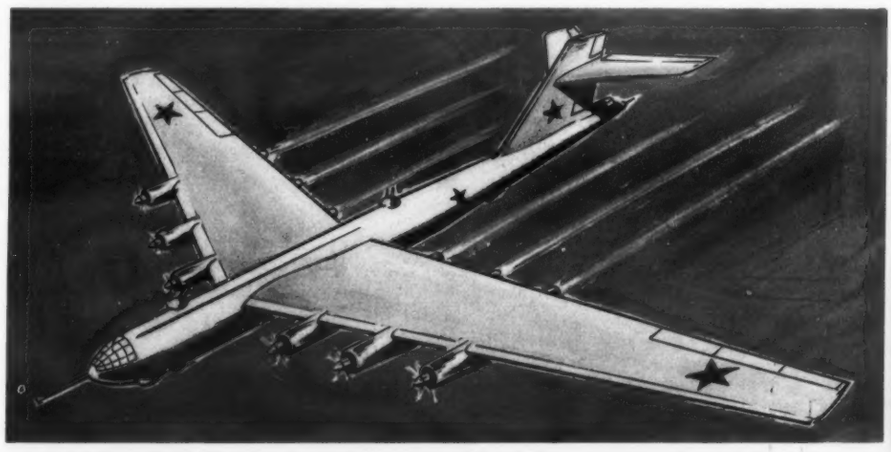
The undercarriage is unconventional. There are tandem pairs of wheels, under the concentrated fuselage loads, with fairly large wheels under *both* the middle and outboard nacelles. This is a fair design point, since a flexible wing structure would have to be used and such wheels relieve the spars of engine weight on the ground. Furthermore, concrete runways are reputedly rare in the USSR and the spreading of ground contact loads would increase operational flexibility.

Engines are propeller turbines, probably developed from the BMW-028, which was well advanced in design in 1945. If this is the case, each unit would provide about 7,000 s.h.p. plus residual jet power—about right for a 550 m.p.h. bomber of this size. For take-off there are 30 rockets—also an aid for short runways.

Bomb load is unknown, but both this and the range probably approximate to the B-36. Defensive armament is heavy, with two dorsal and two ventral barbettes and a tail gun position. There is little doubt that the B-29 armament provided the prototypes for this gear. A crew of 22 is specified and lines up with a 10,000 mile range and such heavy armament. It is a known fact that the B-36 is undermanned without a complete relief crew for very long trips.

Finally, a prototype, powered by DB-626 piston engines was, according to our source, flying as long ago as September 1950.

Length	51 m.
Span	68 m.
Crew	22.
Engines, 6	M-028 Propeller Turbines.
Take-off rockets	30.



The Future Evolution of the Bomber

BY DR. ING. EUGEN SÄNGER, PARIS

Author (left) with model of the German A 10 rocket project, which is today regarded as the preliminary stage for a future earth satellite rocket.

ECONOMIC RESOURCES

Already today the Great Powers' air forces swallow up to 5% of their total social incomes, and engage the efforts of numberless scientists. When, in the not-so-distant future, guided missiles and space weapons come into general use, expenditure even in peacetime will be much higher still. The ancient arms feud, on the one hand between the power groups of the world, and on the other between weapons of attack and weapons of defence, continues unabated.

The growing tension between East and West should not blind us to the fact that the world contains more than just two groups of powers. In the so-called "cold war," India, the Arab countries and Latin America occupy a neutral position. And Western Europe, notwithstanding its increasing economic interrelations with North America, might still under certain circumstances return to a policy of independence. A critical review of their historical development and present ideological, political and economic situation shows that the nations of the world can be divided into *five* main political groups :

I. USA, Canada and Oceania
II. Western Europe and Africa
III. Soviet bloc (Eastern Europe, Siberia and China)
IV. Rest of Asia [1]
V. Latin America (Mexico, Central and South America).

Material equipment

A detailed analysis of the world's material resources would naturally have to begin with a review of industrial workers and a comparison of raw material supplies, steel and power production, etc. The problem is here simplified by giving only the total population of each group and their total annual production (or national income) :

Population and annual national income of the major political and economic groups

Group	*Population (millions)*	*Total national income (million $)*	*Income per head $*
I. USA, Canada, Oceania	170	230,000	1,355
II. Western Europe and Africa	490	140,000	285
III. Soviet bloc	750	100,000	135
IV. Rest of Asia	720	40,000	55
V. Latin America	140	20,000	145
Total (average)	2,270	530,000	225

The above table is based on statistics of purchasing power supplied by UNO. Like the total national income, average wages per inhabitant also vary. Whereas in the United States they are roughly $1.20 per hour, in Europe they are much lower, at $0.30 per hour. The "dollar" unit is thus only a symbol for the value of an hour's work. It should also be remembered that the national income of civilized countries in peacetime is spent on an average as follows : food 30%, housing 20%, clothing 15%, miscellaneous 15%, taxation 20%.

Most countries at present are spending between 5 and 30% of their taxation revenues on their air forces. The proportion of the total national income thus spent is : Group I : approx. 10% ; Group II : less than 1% ; Group III : over 5% ; Group IV and V : negligible. In time of war they would increase considerably—at the expense of food, housing, clothing and "miscellaneous"—in Western Europe for example from their present 1% to 10% (14,000,000,000 dollars). This is assuming that the national income remains roughly unchanged to start with, i.e., before major destruction occurs, and that the men called up for military service are made good by extra effort from those left behind and by the employment of women.

Intellectual equipment

In the development of weapons whose efficacy stems primarily from their technical superiority, the intellectual requirements—level of scientific achievement and spirit of invention—are just as important as material resources. Here it is well to recall the four phases of any major technical progress. These are : *invention, research, development* and *production.*

The days of the propeller-driven bomber are numbered.—The Russian Tupolev Tu-4 heavy bomber.

[1] Group IV (Rest of Asia) is a very heterogeneous collection of states. Certain important states are already closely engaged with the first two groups. For example, Japan, South Korea and the Philippines (approx. 120 million persons) are connected with Group I, the Near East (approx. 50 million persons) with Group II. Whether and to what extent certain parts of Further India (Burma, Siam, Indo-China and Malaya, approx. 60 million persons) will cooperate with Group III, only the future will show.

Turbojet fighters with afterburners (Lockheed F-94 all-weather two-seater fighter) can successfully combat traditional bombers, but will only be able to retain their superiority for a short time when confronted by jet bombers.

The power to produce great *inventions* is largely outside human control and is given only to specially favoured individuals. [2]

Many of the other components of the "intellectual potential," such as skilled workers, experienced supervisors, highly trained engineers and research specialists, can to a certain extent be trained.

The next phase in any new development, *scientific examination of and experimentation with the idea,* is the task of government and industrial research centres. These centres must have sufficient intellectual and material capacity to be able, without waiting for outside instructions, to test promising ideas from the physical and technical points of view, so that they can then be put into practice with the minimum risk.

The actual technical *development* generally necessitates considerable expenditure. The responsible organizer will therefore need great knowledge, foresight and enterprise to be able to judge whether, in view of the available work potential, the project is worth the expense. If he decides that it is, he must have sufficient courage and confidence in the scientist to give immediate and definite instructions for its development. This work is then carried out by development engineers and the leading industrial concerns.

The fourth and final phase, *production,* comes entirely within the province of industry and hence chiefly of the material potential.

Although the great majority of scientific discoveries and technical inventions come directly or indirectly from Western Europe, the Americans are clearly in the lead in research, development and production. Of the other three groups, only the Soviet group, which has a high population, considerable raw material and power reserves, and last but not least gifted scientists and engineers, is at the moment in a position to make independent technical progress.

STAGES OF TECHNICAL DEVELOPMENT

The foregoing brief review of the differences in material and intellectual resources of the nations is essential to the complete understanding of our main subject. Any forecasts of the future development of air and space weapons must start primarily from American projects, and it is above all the aviation research engineer who, thanks to his normal task, is called upon to make such forecasts.

The central points of interest are, of course, the main weapons of attack and defence, i.e., bombers and fighters, or whatever takes their place in the future.

Propeller-driven bombers and turbojet fighters

Intellectually we are still influenced by the situation as it existed at the end of World War II, namely the struggle between propeller-bombers and jet fighters, exemplified roughly by the American B-29 and the German Me 262. Even though the latter appeared too late and in too small numbers, it proved the superiority of the jet fighter to be so overwhelming that the days of the propeller-driven bomber are numbered. It will probably remain in use up to the beginning of the next major war. Meanwhile its successor has adopted the power plant of its mortal enemy.

Turbojet bombers and turbo-ramjet fighters

The jet bombers now under test and beginning to go into production will control the field in the near future. They have a Mach

[2] We Europeans should be proud of the fact that we have so many owners of this power among us. We cannot, however, pride ourselves on the naïveté with which we squander them on the rest of the world, when we have every reason to cherish these sources of our particular European force with the greatest care and to see that we reap their fruits.

number of just under one, an altitude of around 50,000 ft., a gross weight of about 100 tons and a range of between 3,000 and 6,000 miles. Needless to say, ground anti-aircraft guns are useless against them.

Similarly today's jet fighters, which have only roughly the same speed and ceiling as their new opponents (and, what is more, take ten minutes or more to climb to combat altitude) can no longer effectively oppose the jet bomber.

Successful fighter operations have therefore become impossible. The turbojet fighter, which has but so recently become operational, is already technically outdated and doomed to disappear. It is now being replaced by the turbojet fighter with afterburner, whose Mach number is between one and two.

In the lower supersonic range the turbo-ramjet or afterburner power plant [3] has a higher thrust in relation to its frontal area than the pure turbo-jet or pure ramjet, whereas its efficiency is somewhere between these two basic types. It also delivers considerably higher take-off thrusts, but has the disadvantages of all combined types of power plants, namely, it is of complicated structure, costly to build and heavy.

Even the temporary use of this combined form of power plant instead of the pure ramjet would *not* seem justified in the fighter, since the bombers now under development with similar combination power plants will catch up on the fighter's speed advantage only too soon.

Turbo-ramjet bombers and ramjet fighters

The development of very heavy weapons, such as the uranium, plutonium and hydrogen bombs, will limit the heavy bomber more and more to smaller and smaller units of highly specialized aircraft. Economic considerations will therefore play a minor part in the design of bombers than in that of fighters, which must always be provided in the greatest possible number. Whereas the cost of the afterburner power plant with its high thrust is still reasonable in a bomber in relation to the cost of an atom bomb, this is far from being true nowadays in the case of the fighter.

However, it is traditional that a new power plant system is first used in the smaller aircraft, namely the fighter, and later taken over by the bomber, and the present-day trend is no exception to this rule. As an inevitable sequel to today's turbojet fighters with afterburners, we may look for similar bombers in the future, with Mach numbers of between one and two and altitudes of about 65,000 ft. All the fighter systems hitherto mentioned will be powerless against such attackers... Our next question is, how to replace them.

It is typical of man's inertia that a large number of turbine fighter projects are still being worked on throughout the world, whilst the work begun in Germany during the last war on guided rockets for defence (with target-seeking warheads and proximity fuses) and manned ramjet fighters has been relatively neglected. Nevertheless the future defensive weapon against supersonic bombers will stem from one of these two lines of development. It can even be forecast with certainty which of the two will come into use first. Whereas pure ramjet engines have a fuel consumption of approx. *one* kilogram per tonne per second and those with a turbine in front even less, our present-day rocket engines consume about *five* kilograms of fuel per tonne thrust per second.

As long as bombers continue to fly in sufficiently dense atmosphere the power plant of defensive machines can burn the oxygen from the air rather than resort to the much more expensive practice of carrying oxygen, which primarily accounts for a rocket's high consumption. In this phase of development rocket fighters will no be able to offer any effective competition.

On the other hand turbojet engines, especially those with afterburners, can still be used in the low supersonic range, where they have greater efficiency than the pure ramjet engine. The reasons why they do not appear to be suitable for defence against turbojet and turbo-ramjet bombers, are mainly as follows :

1. The supersonic fighter must be able to climb to its combat altitude in not more than two or three minutes, and have a thrust/weight ratio of somewhere about one. Even turbojet engines alone scarcely reach this value at high altitudes, let alone a whole fighter. On the other hand, the ramjet engine, which weighs only a fifth to a tenth as much per unit of power, would appear to be capable of filling these requirements.

2. The temperature range, utilizable for thrust and compression, between the fresh air temperature at the end of the compressor and the permissible fire gas temperature at the turbine blades rapidly becomes smaller as the aircraft's supersonic speed increases. This entails a reduction in thrust in relation to frontal area in the turbojet engine to well below that of ramjet engines, and an increasing reduction in compression power in the afterburner engine. In the ramjet power plant on the other hand the structural materials do not place any limit on chemical heating in the Mach range at present under consideration.

3. This circumstance is also of economic importance, since it permits of a saving of strategic raw materials in quantity production. Supersonic turbine engines, on the other hand, need greater and greater quantities of scarce materials.

4. The lower structural weight of the ramjet engine is also a considerable advantage in a war effort, as it means that production is less costly. The life of a fighter in wartime is only a few hours of combat duty, so that expensive turbojet engines are an extravagant luxury in a short-lived fighter. [4]

5. The need for special starter motors for ramjet engines is sometimes counted as a disadvantage, but is really the exact opposite, at any rate for warplanes. If the very heavy and expensive starter equipment need no longer be carried in flight, thus no longer reducing flight performance or running the risk of being destroyed in battle, and can therefore be used over and over again, this cannot be other than an advantage, both technically and economically. Take-off from mobile catapults will become the rule, particularly when

[3] A turbojet engine with afterburner (turbo-ramjet) works thermodynamically like a turbojet with a ramjet behind it, or a ramjet with mechanical compression in front. From the structural point of view it is also a combination of the two basic engine types.

[4] The importance of financial considerations in purely technical decisions can be illustrated by two examples : (1) the projected production of 20,000 turbojet engines a year in the United States would, assuming each to weigh 2,000 kg and taking the known production cost of approx. $50 per kg in quantity production, cost in round figures $2,000,000,000, or one tenth of the present U.S. Air Force budget ($22,400,000,000). (2) In wartime even if 100,000 fighters were produced every year, with an average life of 10 hours, in uninterrupted operational use, only 114 fighters would be operational at any one time. Yet this production costs about ten thousand million normal working hours, or 10% of the European social product. Their fuel consumption of two million tons on the other hand costs less than a hundredth of this sum. It would therefore seem senseless to use more expensive engines to get a slightly better efficiency when annual production costs can be reduced to less than half by using the cheaper ramjet engine, especially since it also requires less scarce material and gives better flight performance. Thanks to the lower wing loading of the ramjet fighter greater manoeuvrability could be achieved at combat height ; it also has a much greater rate of climb and a good speed advantage up to Mach 3 or 4.

Meanwhile the bomber has taken over the power plant of its arch enemy. The Boeing B-47 "Stratojet" three-seater (six General Electric J-47 jet engines plus take-off rockets) has a speed of about 620 m.p.h., a ceiling of "over 40,000 ft." and a range of up to 3,000 miles. Its take-off weight is 84 tons.

crews disappear from fighters and take-off power is supplied not by expensive power rockets, but by cheap liquid rockets (with high water content in the propellants). We must get used to the idea of regarding the aircraft purely and simply as such, and not as a combined air and ground vehicle.

These arguments, all of them on the side of ramjets, still hold good when, with increasing supersonic speeds, the actual combat is rendered more and more automatic by remote control, target-seeking missiles and proximity fuses. When fighters finally degenerate into unmanned ramjet machines they will be superior to any manned aircraft because of their higher acceleration limits.

Ramjet fighters will at first have an advantage over remote-controlled defence rockets, since the latters' power plants consume five to ten times as much fuel, are more costly to build and require more expensive propellants. Defence rockets can only begin to compete when the density of the atmosphere at the combat altitude no longer suffices to produce full efficiency in the ramjet.

For defence against the sonic and supersonic bombers of the near future in the lower stratosphere the manned or unmanned ramjet fighter is most suited from the point of view of both performance and economy. The manned pure ramjet aircraft developed by the French appear to support this view.

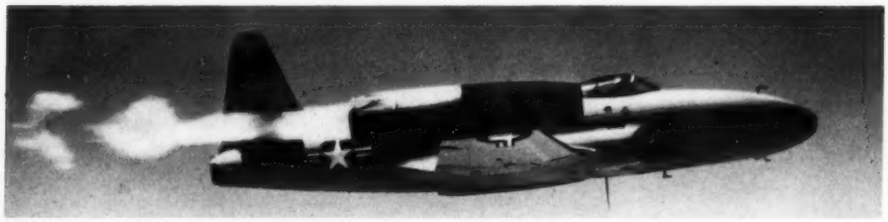
Ramjet bomber and defence rocket

Sooner or later the pure supersonic ramjet engine will also be used in the bomber. In the supersonic range (at Mach numbers of between 3 and 4) propulsion efficiency rises to 40-50% and makes this type of propulsion very attractive for large long-range aircraft which can also be built as commercial aircraft. As soon as the supersonic ramjet fighter renders today's turbojet bomber and its derivative, the combined turbo-ramjet bomber, out of date, because of its superior Mach number, we shall have to be prepared for pure ramjet bombers which will fly at a speed of 2,500 m.p.h. at between 65,000 and 100,000 ft. and with similar ranges to today's giant bombers.

The well-known American wind tunnel projects for the investigation of ramjet power plants for a thrust of 45 tons at Mach numbers of 3.5 support this view. So does the tendency in the United States to supply the afterburner chamber of large turbine engines with fresh air during supersonic flight not via the compressor and turbine but direct from the diffusor, i.e., to switch off the turbine and use the afterburner as an independent pure ramjet.

At Mach numbers of between 3 and 4 the speeds of ramjet aircraft are not limited by the propulsion system but by the boundary layer temperatures of the air stream and the increasing fire gas radiation which makes adequate cooling of the combustion chamber walls and of the cabin difficult. In unmanned machines the cabin problem does not arise, though that of the temperature resistance of the combustion chamber walls and the cooling system remains acute. Here the fighter, which is in the air for only a short period, has the advantage of having to contend with less consistent high temperatures than the bomber.

However, it may be forecast that the arms race will very soon lead to the replacement of the ramjet fighter by remote-controlled defence rockets or unmanned rocket fighters, with any desired speed advantage. With the defence rocket we shall probably have arrived at the end of the conceivable methods of defence against the threat from the air. There are practically no limits to its speed and ceiling, and it could even be used against earth satellite vehicles, for which the regularity of its trajectory and the vulnerability of these vehicles render it highly suited.



Flight tests with ramjet engines in the USA and France: *left*, a Lockheed F-80 "Shooting Star" with Marquardt ramjet nozzles at wing tips; *right*, Engineer Leduc's ramjet aircraft carried by a four-engined "Languedoc."

Rocket bombers

The rule following from the above, that the fighter reaches out for faster and faster propulsion systems (propeller, turbojet, turbo-ramjet, ramjet, rocket) and that the bomber always takes over the power plant from the last fighter system, to increase its own speed, must ultimately lead to the rocket bomber. The qualities of the rocket bomber have already been thoroughly investigated in theory: globe encircling ranges, speeds of up to 16,000 m.p.h., altitudes of several hundred miles. These figures show the rocket bomber to be rather a space weapon than an air weapon. It can also fly an undulating trajectory of irregular form variable at will, so that "pursuit" of the bomber, e.g. by defence rockets, is not easily imagined.

We thus arrive for the first time at a weapon against which, in our present stage of technical knowledge, there is no defence, especially when it is used to carry atom bombs. The question therefore once again arises of whether it will be technically possible to wage wars.

This surprising, yet natural outcome of today's expanding development is in no way bound up with imaginary Utopias.—Ten years ago the idea of a rocket bomber seemed like a technical vision, but now the practical energy of the Americans, with their wind tunnels for Mach numbers up to 15 and their manned rocket aircraft, has done some most effective preliminary work. The maximum speeds of American experimental aircraft have risen during recent years step by step to 620, 1100 and 1500 m.p.h., and other aircraft for speeds of 2500 m.p.h. are projected. Admittedly there are still many technical problems to be overcome before we can get the required 16,000 m.p.h., but no basic difficulties.—The ultimate object of these amazing flying developments is obviously the rocket bomber. And the lively interest shown in this weapon by Field Marshal Stalin makes this supposition seem all the more likely.

The fact that the end of this line of development appears to be not an unconquerable weapon of defence but an irresistible weapon of attack might perhaps prevent the great political groups from rolling up into hostile hedgehogs and shutting themselves off from one another. We tend to the belief that it will be the deeds of engineers which will put an end to war rather than the words of politicans.

However, the rocket bomber also bears the seed of a second important line of development. From its speed of 16,000 m.p.h. to that of the earth satellite vehicle (17,500 m.p.h.) is but a short step. As well as being the final link in the chain of development of the air weapon, the rocket bomber is also the beginning of the development of space travel.

Military aviation inevitably leads into space travel. Quite apart from all philosophic considerations on the sense or nonsense of war, we must admit quite soberly that the technical

development engendered by wars will transform air travel into space travel. On the other hand mankind is unlikely to make the effort in peacetime towards space travel.

When ? And what will it cost ?

Our investigations have thus led us to the following juxtaposition of bomber and fighter systems :

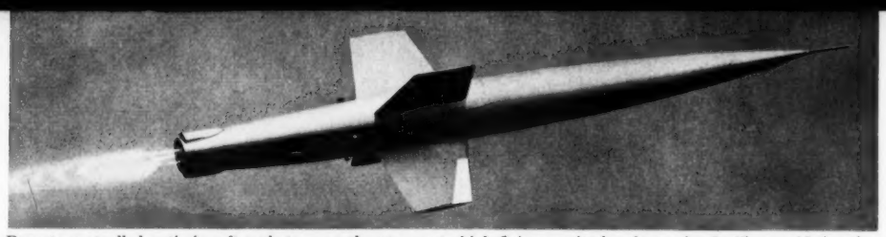
ATTACK	DEFENCE
Propeller-driven bombers (still in use)	Turbojet fighters (still in production)
Turbojet bombers (in production)	Turbo-ramjet fighters (under development)
Turbo-ramjet bombers (under development)	Ramjet fighters (under research)
Ramjet bombers (under research)	Defence rockets (under research)
Rocket bombers (principles under research)	None (not yet invented)

These considerations would be incomplete without some kind of estimate, however rough, of the time required for and the cost of these developments. Up to the present the cost of developing new aviation equipment per kg has been roughly as follows :

Development of a new aircraft of traditional system 1,000 $/kg.
Development of new engine of traditional system 10,000 $/kg.
Development of aircraft of new system 100,000 $/kg.
Development of engine of new system, up to 1,000,000 $/kg.

If we ignore the types already under development, and consider only the systems now in the research stage, beginning with the ramjet fighter, we can calculate the following rough figures for development costs, using the known figures as a basis :

Ramjet fighter	$ 1,000,000,000
Ramjet bomber	$ 5,000,000,000
Defence rocket	$ 2,000,000,000
Rocket bomber	$10,000,000,000
Total	$18,000,000,000



Remote-controlled anti-aircraft rockets are a threat even to high-flying ramjet bombers. An Oerlikon guided rocket (with cruciform wings) taking off from a mobile launching gear.

The trend of development is towards the rocket bomber. According to unofficial reports the experimental Douglas D-558-2 "Skyrocket" fitted solely with rocket engines reached a speed of about 1500 m.p.h. at 70,000 ft. during the summer of 1951. It was released from a Boeing B-29 at 32,800 ft. and then climbed to the test height under its own power.

The individual items alone are as high as the total annual air force budgets of the first three large political groups. It is obvious that such programmes can be undertaken only by the most powerful groups, and that development will of necessity take many years, much to the impatience of the onlooker, to whom everything appears to be too slow.

If the funds available for research and development amount to 10% of air force appropriations, the whole development of the abovementioned four classes of aircraft (including the rocket bomber) under today's "peacetime" conditions would take roughly 18/2.24 = 8 years in Group I, roughly 18/0.4 = 130 years in disorganized Europe and about 18/0.5 = 36 years in Group III. This is assuming that the last-mentioned group has the necessary creative potential. The exchange of knowledge and experience, which always takes place in spite of the most stringent security measures, makes the methods used by one group available to the others and may therefore speed up development in general. In the event of war bigger air force appropriations will also help to cut down development time.

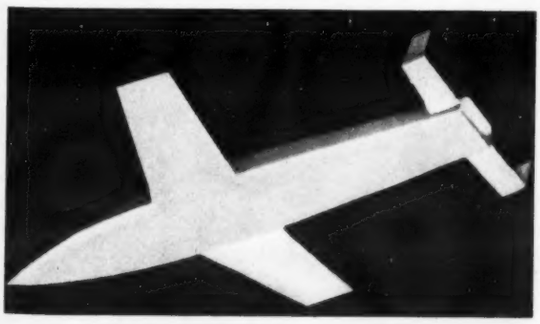
These figures also show that modern air forces can no longer be provided by medium and small nations, but only by great powers or groups of powers.

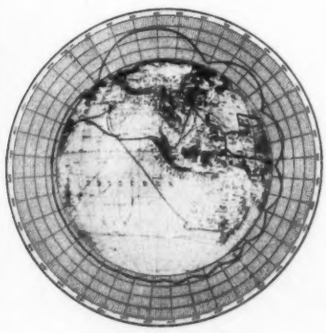
On the other hand it is in the nature of armaments that each group should try as far as possible to keep them for itself. Only when the whole programme has been completed—when excessive threats and counter-threats from all sides make the continued existence of individual political groups impossible—will the technical and psychological conditions be achieved for all mankind to concentrate their efforts on the first practical steps towards space travel. Then an earth satellite vehicle, whose estimated cost will be anywhere from ten to a hundred thousand million dollars, could be constructed. With the same expenditure as today, i.e., with present air force budgets, such a vehicle could be built within perhaps 100/13.3 = 8 years, if the whole world cooperated.

*

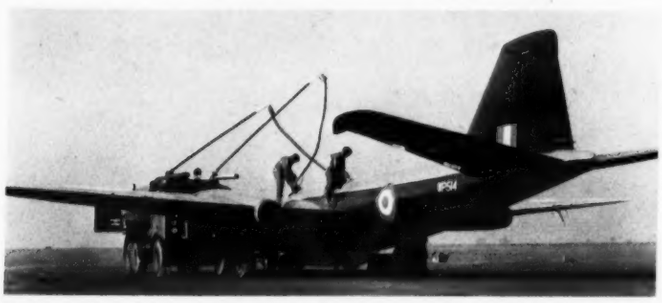
This singular mechanism of technical development—conditioned by mankind's psychological reactions—may seem amazing to many people. Unfortunately this amazement will not spread to all until the end of the process. It is therefore almost too much to hope that the process of development towards space travel via the detour of air weapons will be cut short by wise decisions.

In the present state of technical development there is no defence against the rocket bomber. The rocket bomber on the left (designed by the author) could fly round the world on an undulating trajectory at a top speed of about 17,500 m.p.h. and drop an atom bomb weighing 3.8 tons a great circle distance of 12,000 miles away, from an altitude of 130,000 ft. It would be back at its home base after 150 minutes of flight.





A "Canberra" of No. 101 Squadron in flight at Binbrook, Lincs.



Fuelling the "Canberra." This reveals the previously "classified" location of main fuel tanks. Ground crew wear their new weatherproof clothing.

A crew getting ready for take-off.

Jet Bomber Squadron

The first operational jet bomber unit in Western Europe was established in England in the latter part of last year : No. 101 Squadron of the Royal Air Force, stationed at Binbrook RAF Station, Lincs. Its equipment consists of English Electric "Canberra" Mark 2 twin-engined light bombers, a type which at various public demonstrations has gained a reputation for its manoeuvrability, speed and range. The RAF states that it "will be able to carry a considerably more destructive load than the average World War II heavy bomber"—which seems to imply that the type can be regarded as the first, or at least one of the first, of the "poor man's 'a'-bombers," as outlined by Colonel Gallois elsewhere in this issue. A second squadron, No. 617, also stationed at Binbrook, is now converting on to "Canberras."

No. 101 is not the world's first jet bomber squadron. The Americans had some North American B-45 "Tornado" light bomber units some time ago, but these are now used for photographic reconnaissance duties ; meanwhile, the Boeing "Stratojet" medium bomber will shortly go into squadron service. In Europe, the Russians have been operating a substantial number of Tupolev Tu-10 light tactical bomber squadrons for some time, and training flights from East German airfields are a daily occurence.

The introduction of the "Canberra" into squadron service heralds the start of an expansion of RAF Bomber Command and not merely a re-equipment programme. Selected crews from existing Avro "Lincoln" and Boeing B-29 "Washington" (i.e., "Superfortress") heavy bomber squadrons will form new "Canberra" units. The piston-engined bombers themselves will later be replaced with Vickers "Valiant" four-jet medium bombers.

Conversion from piston-engined bombers is still being carried out at Binbrook station, but an Operational Conversion Unit will be formed this year at Bassingbourn, Herts. After a course of ground instruction, pilots first fly the Gloster "Meteor" twin-engined jet trainer and then complete 15-20 hours' solo flying on a "Meteor 4" fighter. Initial flights in the "Canberra" are made with an instructor sitting next to the pilot (the aircraft, like all other British bombers, has no dual controls). This careful training is mainly to familiarize the pilots with jet technique—low drag and deceleration, air brakes, acceleration lag on opening up (due to the axial-flow "Avons,") rapid climb, and so on. The "Canberra" is generally conceded to be a simple and pleasant aeroplane to handle, and National Service pilots are slated to join No. 101 and the other squadrons.

At a recent press visit to Binbrook, the squadron showed complete confidence in its new mounts. Binbrook is a very cold, bleak aerodrome

Pilot is already in his cockpit, navigator and observer are on their way to join him.

Navigator and observer enter by the rather small door.

Fitting the starter cartridge to one of the "Avon" engines.

Flight-Lt. P. D. ("Pat") Walker, No. 101 Squadron training officer, in his new high-flying kit: pressure waistcoat, connection on right breast, large-diameter oxygen tube, and anti-glare vizor.

Nose of "Canberra," with plate-glass bombardier's panel.

on a plateau that gives excellent clear approaches for jets. Take-off was smooth, and so was the formation flying, although this is not normally a requirement and was "laid on" purely to please the press. Despite its manoeuvrability and because of its cleanness, the "Canberra" does not take too kindly to formation flying.

The first task of No. 101 Squadron is to carry out intensive flying trials of a new character in accordance with a recent Air Ministry decision. These trials will involve the aircraft being flown at two or three times the intensity of normal peacetime squadron routine. By flying an aircraft type under the most exacting conditions, a reliable indication of the operational potentialities can rapidly be obtained—in plenty of time to incorporate minor alterations in the machines which will shortly begin to roll off the production lines in quantity.

The crews of No. 101 are experimenting with new equipment, including amber anti-glare vizors instead of goggles. These are intended to improve vision at high altitudes and also to give additional face protection in the event of bailing-out. "Crash helmets," like those issued to USAF personnel, are not used by the "Canberra" crews any more than they are by RAF jet fighter pilots. The crews have pressure waistcoats which are connected to the aircraft oxygen supply, so that, by applying pressure to the diaphragm, they aid breathing at great heights. Officially, these waistcoats are said to be for emergencies such as cabin pressurization failures at great heights, but one imagines that the "Canberra," like most fighters, the "Superfortresses" and the B-36, will go into action unpressurized in order to avoid the detrimental effects of sudden decompression in the event of a puncture of the fuselage shell. Under such conditions, probably at 50,000 feet or so, any crew member having to move about in the aircraft will certainly need his pressure waistcoat.

Refuelling at Binbrook disclosed that the main tanks are in the fuselage, a fact which previously had been "classified." A most curious method has been evolved for bombing up this very low-slung aircraft, but that still is a "classified" operation.

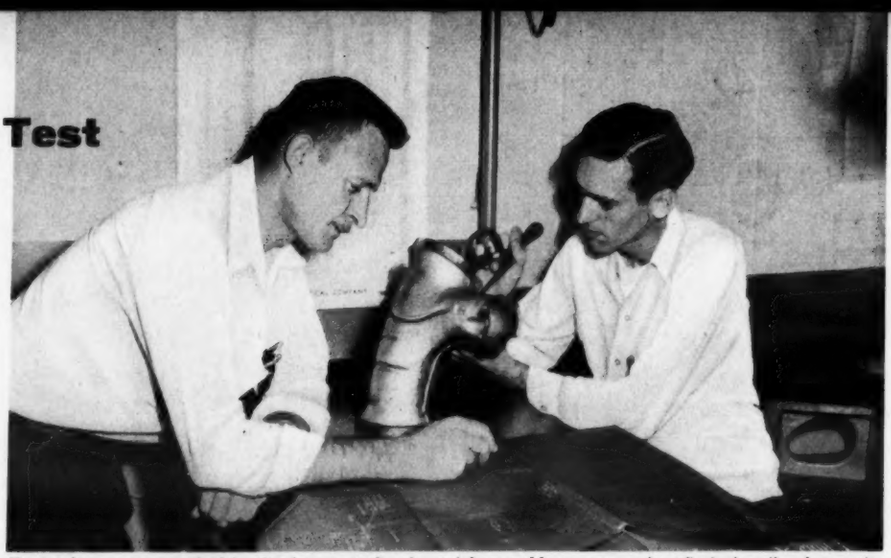
No. 101 Squadron was originally formed in July 1917 and operated in France as a night bomber unit. During the last war it first flew Bristol "Blenheim" light bombers, later Vickers "Wellington" mediums, and finally Avro "Lancaster" heavies. It was one of the units taking part in the attack on the German research stations at Peenemunde in August 1943. No. 617, the second "Canberra" squadron, was formed in March 1943 under the command of Wing Commander G. P. Gibson. Its first task, one of the most daring of the war, was the breaching of the Mohne and Eder dams in May 1943. During the next few months it operated with great success against small, specially selected enemy targets, mainly single factories. It took part in the bombing preliminary to the cross-Channel invasion.

Left to right: Squadron-Leader W. H. Thallon, Officer Commanding No. 617 Squadron; Group Captain N. C. Hyde, Station Commander, Binbrook; Wing Commander H. P. Connolly, in charge of Flying; S/L. E. Cassidy, O. C. No. 101 Squadron.

Line-up of some of No. 101's "Canberras." Two "Lincolns" in the background at far left.

Titanium Takes the Test

RYAN AERONAUTICAL COMPANY SAN DIEGO, CALIFORNIA



Closer tolerances are required for titanium parts than for stainless steel because excessive "Springiness" makes mating more difficult. Ryan spot weld Engineer Frederick Dever (left) and metallurgist Dave Adams (right) check dimensions of Piasecki shroud section which Ryan fabricated from titanium.

Titanium—most modern metal of industry—is nature's paradox. More than any other element, this metal seems to exhibit exasperatingly contradictory behaviour. Neither new nor rare, it costs the fabulous price of $15.00 per pound. With an extremely high melting point for its weight—higher than steel—it still will not withstand continued use at high temperatures. So "affectionate" for other elements that it is never found free, and instantly combines with other substances when molten, it will not weld with any other metals by known processes.

In spite of this "Dr. Jekyll and Mr. Hyde" complex, titanium is endowed with some of nature's choice characteristics which seem to be especially planned for aircraft applications. Because titanium falls between the aluminium and steel alloys in both strength and resistance to temperature, it is the answer to many of the aircraft designer's problems. For years, engineers have been forced to specify heavier steel alloys in the design of structures which required more strength than aluminium alloys could provide at elevated temperatures. Because the aluminium alloys lose strength rapidly at temperatures above 150° C (300° F), this meant that a wide variety of components, such as fire walls, ducts and shrouds, had to be built of stainless steel.

Titanium retains its exceptional strength up to temperatures of approximately 430° C (800° F). It weighs only 56 percent as much as steel and approaches the best steels in strength. Some titanium alloys can now provide 175,000 p.s.i. (123 kg/mm²) tensile strength and new types with 200,000 p.s.i. (141 kg/mm²) are being developed. With a lower linear coefficient of expansion and thermal conductivity than either aluminium or steel alloys, titanium is the only metal known to have an endurance strength consistently in excess of 50 percent of its tensile strength.

One of the companies which have been conducting intensive research into the use of titanium is the Ryan Aeronautical Co., which has used established procedures for stainless steel to form intricate structures of titanium. At the Ryan Development Laboratories, flat sheet was formed to complex shapes to shroud the high temperature exhaust system which the company builds for the Piasecki HUP-1 helicopter. This part operates at a temperature of 210° C to 260° C (400° F to 500° F), and appears to be an ideal application combining the weight-saving and heat-resisting qualities of the metal. Also, it involves severe forming and resistance welding.

One of the basic aims of the investigation was to determine the adaptability of machines and procedures used in forming stainless steel components to the forming of titanium parts. Obviously economic advantages could be gained if conversion from stainless steel to titanium fabrication could be made without extensive re-tooling.

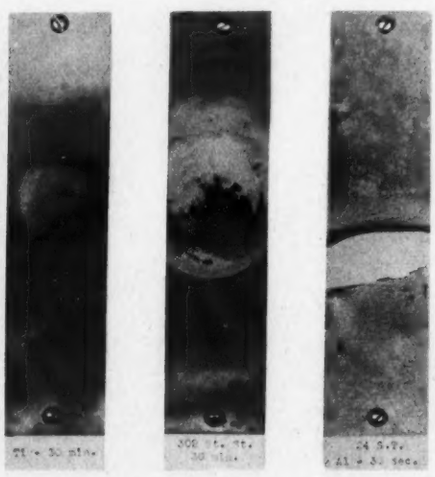
Little information is available on the production forming of titanium, due to the fact that it made its commercial debut in 1946 and only 60 tons of the metal were refined in 1950. The Ryan laboratory established an experimental production procedure to determine the behaviour of titanium when welded, formed and heat-treated. To check the effectiveness of cold forming plus annealing and hot working of titanium, a number of sheets of .018" and .037" metal were used.

A spherical cavity was machined into a steel plate. The diameter of the cavity was $^3/_4$ inch and the depth $^7/_{32}$ inch. By measuring the total deformation possible after forcing the titanium into the cavity with a steel ball, using an impact load, it was possible to obtain quantitative evaluation of various annealing and pre-heat treatments. The following results were tabulated :

Deforming Temp.	*Treatment*	*Deforming Characteristics*
Room	None	Cracked when deformation was about 50% complete
Room	Deformed 50% of possible, annealed 1 hr. at 635° C (1170° F), deformation then completed	No cracking
Room	Deformed 50% of possible, annealed 40 min. at 635° C (1170° F)	No cracking
Room	Deformed 50% of possible, annealed 20 min. at 635° C (1170° F) deformation then completed	Cracking appeared imminent
235° C (450° F)	Previously heated to 710° C (1300° F)	Cracked when deformation was nearly complete
345° C (750° F)	None	Cracked when deformation was about 75% complete
540° C (1000° F)	None	No cracking
710° C (1300° F)	None	No cracking

In experimental assembly of shrouded Piasecki exhaust system the fit of all stainless steel and titanium components is checked. This system channels the hot exhaust gases from the Continental R-975 engine which powers the HUP-1 helicopter. Engine is "buried" in the aircraft for aerodynamic and dynamic reasons.

Dramatic evidence of titanium's heat resistance, for limited intervals, is this Rem-Cru Titanium photo of three test strips of titanium, stainless steel, type 302, and Alclad, 24ST aluminium alloy. All were exposed to 1100° C (2000° F) flames. The Alclad disintegrated in 30 seconds. The titanium strip showed less effect than the stainless steel after 30 minutes of this fiery blast.



These tests indicated that either alternate cold forming and annealing, or hot forming would be feasible. If cold forming and annealing are used, the point at which the part should be removed from the die is critical. Photograph shows a cracked port section, partially formed in this manner.

In hot forming procedure, the part was placed in one end of the body half-stamping die, heated to medium red heat and deformed almost to completion. The part was then reheated and deformation completed. No springback occurred. A noticeable amount of lead adhered tightly to the surface which was struck by the lead punch. The part was successfully formed by drawing, heating and hand-working in successive operations. The initial draw was fairly deep and entirely satisfactory.

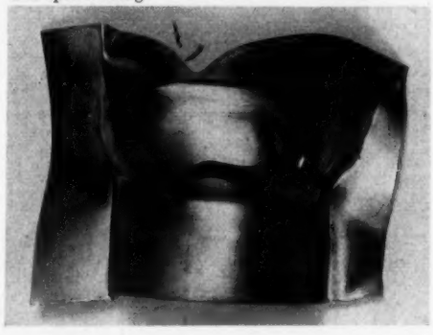
An attempt was made to cold form two supports from the .037″ material. The metal was placed in the die and hit several times. Forming was satisfactory except for a springback of about 1/8 inch measured at the ends. Annealing did not alleviate this condition. The thickness loss was found to be from .002″ to .003″ at the points of maximum deformation.

The scale on the hot formed parts was removed by placing them for five minutes in a salt bath descaling tank which consisted of a mixture of sodium hydroxide and sodium nitrate at 455° C (850° F). After rinsing, they were dipped for 30 seconds in a cold pickle solution of 46 percent nitric acid and 8 percent hydrofluoric acid to remove the titanium dioxide which formed in the salt bath.

Good spotweld results were obtained, in spot welding titanium to itself, with machine settings which produced penetrations from between 70 percent and 90 percent. Sheet values were approximately 650 pounds for the .018″ commercially pure titanium and 1300 pounds for .037″ combinations. No success was experienced in spot welding titanium to other metals.

From these experimental investigations, Ryan development engineers are convinced that most stainless steel forming techniques can be adapted to the fabrication of titanium parts, similar to the Piasecki shroud. The metal should be deformed at temperatures between 450° C and 540° C (800° F and 1,000° F), preferably closer to the maximum temperature. Although lead dies are not practical, because of the lead pick-up, steel or cast iron dies should prove satisfactory. Heated dies would be desirable and economic for large-run production. Use of a controlled atmosphere furnace would prevent the formation of most scale due to heating.

Close-up view of part of the Ryan-designed exhaust system shroud section for the Piasecki HUP-1 engine installation. Note the complex, deep-drawn contours and spot welding.



Cracked titanium shroud forming which was made by a procedure involving cold forming and annealing. Crack was caused by difficulties in determining cold-forming limits of the metal in the die. For this reason, hot forming is more desirable.

Although discovered back in 1791 by an English clergyman named Gregor, titanium was not produced commercially until 1946 when William Kroll, U.S. Bureau of Mines engineer, evolved a process for separating it from its ore. A clue to the tremendous affinity which titanium has for other substances can be gleaned from the fact that the ore can be purchased in the market at only two cents a pound but the refined metal costs from $10.00 to $20.00 per pound. Major U.S. sources of the metal, which is still produced on a very limited basis, are Titanium Metals Corporation of America and Rem-Cru Titanium, Inc. Another company, Horizons, Inc., is hard at work on a new process for refining titanium which promises to reduce its present production costs by 80 percent.

Greatest immediate use for titanium and its alloys will undoubtedly be in the formation of aircraft "skins," or surfaces, for supersonic planes. Friction induced heat is now raising temperatures of these high speed aircraft to well above the limits of aluminium alloys. Titanium could handle these critical temperatures with ease and buoyancy.

Keenest disappointment which titanium has caused metallurgists, who looked with relish upon its 1740° C (3150° F) melting point and hexagonal crystalline structure, is its inadequacy to withstand continued temperatures above 540° C (1,000° F). For short periods, titanium behaves beautifully. At exposures to 1100° C (2,000° F) flames, aluminium plates disintegrated in less than one minute and titanium showed no adverse effects after 30 minutes exposure. Upon cooling to room temperature, it had regained its typical annealed strength.

However, under continual temperatures of more than 540° C (1,000° F) titanium suffers an irreversible absorption of oxygen and nitrogen which rapidly reduces its ultimate and yield strengths and causes it to become brittle. If this deficiency could be overcome, so that titanium would remain useful up to temperatures of 850° C (1600° F), a whole new field of applications would be uncovered. Combustion chambers, inner and outer cones, tailpipes and transition liners for jet engines would use large quantities of the metal.

Ryan development engineers and metallurgists are now working on this avenue of research. Because titanium's deterioration at continued high temperatures appears to be due to events which occur at the surface of the metal, great hope is held for its future in these hot spots if something can be done to protect its surfaces against oxidation and absorption. Ryan metallurgists are experimenting with new ceramic coatings on titanium to determine the success of these materials which have been beneficial in preventing the oxidation of stainless steels at very high temperatures. The outcome of these important evaluations may have an important influence upon the employment of titanium in these specialized fields.

Titanium production is still relatively small. Allegheny Ludlum Steel Corporation's Light Rolling equipment is used to produce these valuable, eagerly sought sheets. Only 60 tons were refined in 1950 but substantial increases are now expected.

Artificial Satellites — Key to Space Flight?

BY L. N. THOMPSON, B.SC., G.I. MECH.E.

Since about the end of the 1939-1945 war, there has been considerable speculation and discussion in both the popular and technical press on the subject of interplanetary spaceflight. This speculation has been stimulated by two recent spectacular scientific achievements, namely, the advent of giant long-range rockets as a weapon of war, and the development and application of atomic power in both the military and industrial fields. In more recent years, since about 1948, interest in the subject has been further aroused by official announcements in the United States to the effect that theoretical studies are being made into the problem of establishing satellite rockets in orbits about the Earth. Although known officially as the "Earth Satellite Vehicle" (E.S.V.) Programme, this project has already received the inevitable nickname of the "Spaceships" programme. In view of these developments an examination of the basic problems involved in the conquest of interplanetary space may be of interest.

"Escape Velocity"

The term "escape velocity" is one which will often be encountered in discussions on spaceflight. Although some mathematical treatments of the term may appear formidable at first sight, the fundamental concept involved is actually quite simple. "Escape velocity" is merely that velocity which a body must possess if, when projected outwards from the surface of the Earth, it is to escape completely from the influence of the Earth's gravitational field. This field reaches its maximum strength at the Earth's surface, decreasing with distance out from the surface, but theoretically does not reach zero strength until an infinite distance out is reached. However, once escape velocity is attained, a body possesses sufficient momentum to enable it permanently to overcome this field, and as escape velocity for planets such as Earth could be reached from rest in a relatively short time, the motors of a spaceship would therefore only need to operate for this short time. This fact will obviously be of great importance from the point of view of fuel economy.

The physical meaning of escape velocity may be easily appreciated if one considers the analogy of a cyclist or motorist at the foot of a steep hill, and imagines that the cycle or car is allowed to freewheel the moment the foot of the hill is reached. Depending on the velocity which the vehicle in question possessed at the foot, the momentum of the vehicle would either carry it right up to the crest of the hill and just over, or else it would travel part of the way up, stop, and then commence to roll back again to the foot. If the height of the hill is considered as corresponding to the work done against the gravitational field, and the vehicle to the spaceship, then escape velocity would correspond to the velocity which the vehicle would need to possess at the foot of the hill if it were just to reach the crest and not roll back again. At any velocity below this minimum value, the vehicle (spaceship) would roll back eventually to the foot (Earth surface).

The escape velocity in the immediate vicinity of the Earth has a value of about 25,000 miles per hour (neglecting air resistance). A spaceship accelerating radially outwards at an acceleration of about 3 g would attain this velocity in six or seven minutes. Increased acceleration would reduce this time, but 3 g would be a reasonable figure from the point of view of physical well-being of the crew of the spaceship. After escape velocity was reached, the spaceship could shut down its motors and it would then just decelerate outwards into space. It would never fall back to Earth, as its momentum would always be too great. Continued operation of the motors beyond the escape point would only cause the spaceship to move outwards more rapidly than it would otherwise have done.

How to Land

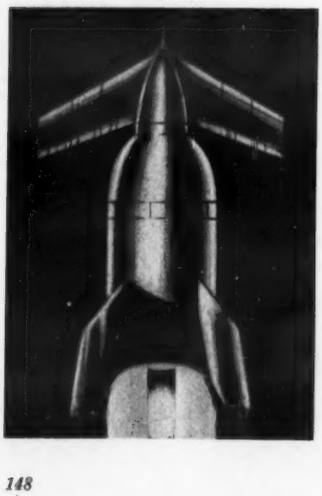
On approaching the destination planet, the spaceship would repeat the take-off procedure in reverse. The ship would be turned end-to-end with the motors pointing towards the planet, and the rocket jets would be used to slow the ship down and finally bring it to rest on the surface. This would be the only possible landing procedure on planets without an atmosphere (readers who saw the motion film "Destination Moon"[1] will recollect that this technique was adopted there for landing on the Moon, a satellite possessing little or no air), but if an atmosphere did exist, aerodynamic advantage could possibly be taken of this by fitting wings to the spaceship and using the braking effect to assist the landing, hence saving fuel.

It will therefore be appreciated that a spaceship would only need to operate its motors for a very small percentage of its total flight time, if maximum economy is desired. This will always be the case, of course, but it introduces the disadvantage of extremely long flight times. To fly from Earth to Mars, for example, would take about eight months, of which perhaps only about a quarter of an hour altogether would be spent under rocket power, the remainder of the period being passed in free fall between the planets. Practical space-travel will obviously be far removed from that pictured in popular science-fantasy!

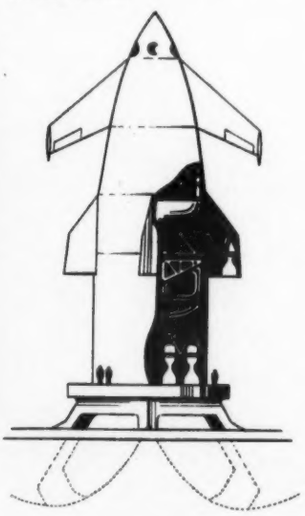
To return to the level of present-day rocketry achievements, it is a sobering thought when one recollects that the German A4 rocket (V2) achieved a top speed of only about 3,400 miles per hour. Since escape velocity for Earth is 25,000 m.p.h., it is easy to see why spaceflight has not yet been achieved.

True return spaceflights, however, will obviously require a much greater energy expenditure than that required merely to achieve terrestrial escape velocity. Landing and take-off at destination, course corrections and transfers between planetary orbits, and landing back on Earth, will all increase the energy requirements. When all these factors are taken into account, calculations show that for any reasonable payload, a spaceship, powered by any of the chemical fuels now available or likely to be available in the future, would have to be of

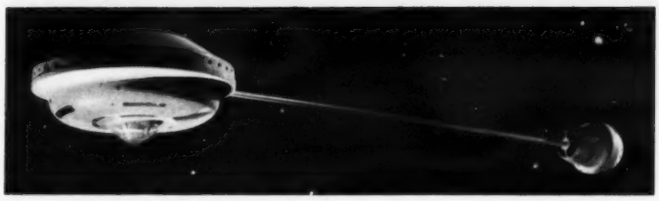
Three-stage supply rockets for a useful load of 40 tons (in the final stage), such as figure in Dr. W. von Braun's suggestions for the construction of spaceships in a sub-orbit of the earth. Each rocket would have an initial weight of 6,400 tons. (Drawing by H. Hähnel.)



Four-stage supply rocket for use in the construction of a space station (according to Hoppner and Kölle), 147 ft. in length. The rocket resting on its launching platform. As in von Braun's project the final stage is fitted with swept wings for the return to earth.



[1] Cf. *This Moon Madness*, by SCHOLER BANGS, *Interavia Review*, No. 10, Vol. V, 1950.



This is what an earth satellite vehicle might look like (according to E. Menzel). The absence of the effect of gravity on the crew (and their circulation, digestive system etc.) is partly compensated by centrifugal force, since the cabins rotate on a long tube about the central body. (Picture from the German documentary film "Space Rockets"—"Raketen im Weltraum.")

much too great a take-off weight to be at all practical. As chemical fuels are therefore inadequate for surface-to-surface return spaceflights, attention has naturally turned to the possibility of using atomic power to drive spaceships.

Atomic Power Plants?

Here again, however, an impasse is reached. Vast power potentials are available from nuclear reactions, more than adequate for spaceflight purposes, but the practical difficulties of harnessing this power appropriately are almost equally vast. The only way of using nuclear energy for space-drive applications at all practicable at present is to use this energy to heat up an inert gas to high temperatures, the gas being then expanded and accelerated in a rocket-nozzle in the normal fashion. However, the extent to which this method could be applied is limited by the maximum temperatures permissible. As these maximum temperatures are of the same order as for existing chemical rocket motors, due to the physical properties of the engineering materials which must be used, any conceivable atomic motors of the above type could therefore not show any improvement in performance over their chemical counterparts. The only hope for the efficient utilization of nuclear energy by these means is the possible development of materials capable of withstanding very high temperatures indeed.

This present inability of conceivable atomic motors, coupled with the permanent inadequacy of chemical motors, to render surface-to-surface return spaceflights feasible, has therefore caused theoretical studies to be made into the possibility of applying sub-orbital satellite techniques to reduce to reasonable engineering proportions the requisite weights of true spaceships. By means of these techniques a given spaceflight can be theoretically performed in several relatively easy stages, instead of in one extremely difficult attempt.

Sub-orbital Satellite Techniques

Satellite rockets and artificial satellites ("space stations") are constrained to remain at a fixed distance from the surface of a planet by causing them to rotate in a fixed sub-orbit about the planet at such a velocity, known as the "sub-orbital velocity," that centrifugal force exactly balances gravitational attraction. This principle is exactly the same as that by virtue of which the Moon orbits about the Earth. Once established in its orbit, the satellite will remain there permanently without further power expenditure (as does the Moon), provided that the orbit lies completely outside the atmospheric belt in order to eliminate all air resistance energy losses.

Sub-orbital velocity in the immediate vicinity of Earth has a value of about 18,000 miles per hour (neglecting air resistance). As this velocity is more than two-thirds of terrestrial escape velocity (25,000 m.p.h.), a spaceship commencing an interplanetary flight from such a sub-orbit (and hence possessing the corresponding sub-orbital velocity) would obviously require much less fuel, and hence would be much smaller and lighter, than a spaceship commencing its flight from the Earth's surface. The continued application of this "stage-by-stage" sub-orbital technique at both the destination planet and on the return flight would then enable the requisite overall initial weight of the spaceship to be considerably reduced.

An example of the application of these orbital techniques to spaceflight was given in a paper by Dr. Wernher Von Braun, originally director of the German Peenemunde research station which was responsible for the design and development of the V2 and other rocket weapons, delivered to the Second International Congress on Astronautics organized by the British Interplanetary Society in London in September, 1951. The paper described a theoretical 70-man return expedition to the planet Mars, chemical fuels being used throughout.

This project would commence with the assembly and fuelling-up of ten non-streamlined (unnecessary as these ships would never be required to enter an atmosphere) spaceships in sub-orbit about Earth. These spaceships would each weigh about four thousand tons when fully assembled, the components and fuel necessary for their construction and propulsion being ferried up into sub-orbit by giant three-stage supply rockets, each of an initial weight of 6,400 tons. About fifty of these supply rockets would be used during the eight-month construction period, during which about 950 ferry flights would be made, each supply rocket being used several times. All three steps of each supply rocket would be recoverable.

After the spaceships were assembled in sub-orbit, their motors would be used to accelerate them up from sub-orbital velocity (18,000 m.p.h.) to escape velocity (25,000 m.p.h.). Then would follow the long period of free fall towards Mars, the spaceships finally taking up a new sub-orbit about Mars.

The actual descent on Mars from the sub-orbit would be made by about 50 members of the expedition in small 200-ton rockets carried out from Earth inside the main spaceships. After a period of exploration, return to the sub-orbit would be effected by the same means,

Editor's Note:

With few exceptions, students of the possibility of space travel agree with the author that interplanetary voyages are still very, very far away. One of the most notable exceptions to the rule is the imaginative but entirely unrestrained Major Alexander de Seversky, former aircraft constructor, air war visionary and pilot, who told a University of Buffalo audience that "within the next fifty years Americans will be flying to the moon in atomic-powered spaceships." These spaceships would reach their destination in three-and-a-half hours at a top speed of 140,000 miles per hour. Unfortunately, the Major did not specify how he calculated the figure of "50 years," or what kind of prime mover and propellant would be used to attain a speed of 140,000 m.p.h.

A more objective appraisal of space travel appeared in Boston's "Christian Science Monitor," one of the best U.S. newspapers, early in January. There is a long road to be travelled before astronautics can turn into a practicality, the paper says—a road which will have to be hewn through a tangled jungle of vexing technical problems. None of the advances of the past twenty years makes space navigation possible, although they are a long step forward. "Twenty years ago space travel was a dream," the paper concludes, "and those who grasped something of its meaning burned with enthusiasm and hope. Today it still is a dream, but the enthusiasm has been fired to an intense heat."

It seems, therefore, that the engineers regard space navigation as technically feasible at some remote date. But those who have studied the physical equipment of the human animal which is to take part in these flights to the moon and other planets, namely the biologists and physiologists, are much less certain that man will ever be able to travel into space—and come back alive. They claim it to be unlikely that many human beings will be able to withstand the prolonged acceleration needed by a space vehicle to attain its escape velocity, and they point out that even the pilots of present-day jet fighters must already be heavily protected against the detrimental effects of rapid acceleration.

In the German weekly newspaper "Die Zeit," Dr. A. Gettkandt, a biologist living in Hamburg, last December expressed serious doubts about man's ability to live under the conditions prevailing in space. Some engineers, he points out, predict that a spaceship will have to be rotated continuously to compensate for the missing gravity effect, necessary for normal life, and he fears that this rotation will have a detrimental effect on man's organs of balance. He also states—the source of this information is unknown—that shortly after take-off the moon travellers will begin to suffer from such intense headaches that they would prefer to be dead... Finally, Dr. Gettkandt draws attention to the practically unknown effects of cosmic rays on the human body.

Thus it seems that the experts are in complete disagreement on the practicability of space navigation. This is not surprising if it is considered that virtually no practical data on the subject are available. At any rate, the layman will have to accept the fact that manned spaceflights are a matter of the very remote future, and would-be "escapists" will have to resign themselves to putting up with living conditions on our own planet for another little while...

all the small rockets being eventually abandoned, either in Martian sub-orbit or on the surface of Mars. Three of the main spaceships would also be abandoned in Martian sub-orbit, as the remaining seven could now accommodate the expedition with its remaining supplies.

These remaining spaceships would then return to Earth, finally taking up again their original sub-orbit about Earth, the crews being ferried down to the surface by some of the original supply rockets. At no stage in the expedition would the main ships land on planet surface. The whole expedition, excluding the eight months initial construction period, would last almost three years.

Space Travel will be Expensive

It will therefore be seen that these sub-orbital satellite techniques offer considerable hope for the achievement of spaceflight, if the expense incurred is not considered to be important.[2] This financial aspect of the question is of course the great snag in the application of these orbital techniques, as there is no doubt that return interplanetary spaceflights untertaken by these means would be extremely expensive, even for expeditions subsequent to the initial one, after which it would not be necessary to duplicate some of the preparatory work and hence expenditure (for example, the original supply rockets and perhaps the spaceships could be used for new expeditions). There would appear to be no hope of interplanetary travel ever becoming commonplace if orbital techniques using purely chemical fuels have to be employed. Space expeditions would be of almost purely scientific value only, and would be of the nature of "once only" attempts.

Probably the ultimate lasting value of sub-orbital techniques will be their use in conjunction with high-performance atomic rockets, should it ever prove possible to construct these. The inherent theoretical economy of such rockets (particularly when using working fluids such as water, in the form of superheated steam propulsion jets), coupled with the advantage of reduction in individual rocket sizes and weights which is characteristic of the application of orbital techniques would almost certainly render interplanetary travel the reasonably economical proposition which it must become if it is ever to be of any real value.

[2] W. v. Braun estimates the fuel requirements alone for the Mars expedition at 5,320,000 tons for the ferry service and 36,000 tons for the actual interplanetary flight; the cost of the building material has not even been estimated.

Summing Up

The following conclusions may be made regarding the question of interplanetary travel:

(1) Surface-to-surface interplanetary return spaceflights utilizing chemical fuels are not possible.

(2) Similar flights utilizing atomic motors of the type which appear feasible at the present level of scientific and engineering achievement are also not possible. In fact, such motors would not be even as good as existing chemical rocket motors.

(3) Notwithstanding this, the energy released by nuclear reactions is more than ample for all the requirements of interplanetary flight. The difficulty lies in the problem of the efficient practical utilization of this energy. If high performance atomic motors can be constructed, interplanetary travel will be both feasible and economical.

(4) Sub-orbital techniques in conjunction with chemical fuels afford a means of achieving a form of space travel, but this method would be so expensive that it would almost certainly be impossible to use it as a basis for regular spaceflights.

(5) If true interplanetary flight ever materializes and becomes reasonably commonplace, it will most probably be achieved by a combination of high performance nuclear rockets and sub-orbital techniques.

1952 Aviation Prospects *

CANADA

Ottawa, February.—Canadian aviation, both military and civilian, is in the midst of its greatest peacetime expansion. It has been deep in the throes of this build-up all during 1951 and will be even more so during 1952.

The same applies to Canadian aircraft industry. Existing plants are expanding and new ones are planned. In research, Canada is moving into new fields under the aegis of the National Research Council at Ottawa.

On the scientific side, Canada with its far northern wastelands, is the scene of joint Canadian-American tests aimed at giving more information on Arctic flying. All this, together with other general aviation and aviation progress, is a part of the over-all Dominion plan of defence preparedness.

Service Aviation

The Royal Canadian Air Force is today in the process of an expansion aimed at a modern fighting force of 40 squadrons, equipped with the latest aircraft. The expansion programme will cost $5,000,000,000 and will be spread over three years. Large contracts have been placed for Canadian-built jet fighters, and large numbers of World War II aircraft have been removed from storage. New operational and training bases are being built, and new squadrons are being formed as quickly as aircraft can be obtained.

A radar system is taking form across the north country at undisclosed points and is tied in with Canada's Air Defence Command, the fighter headquarters for the Dominion at St. Hubert on the outskirts of Montreal. Liaison between this command and its counterpart in the United States has been tightened, since in the event of war the Canada-United States boundary would be considered non-existent if defence had to be concentrated in the north.

Main emphasis by the RCAF is being placed on interceptor forces and a majority of the 40 squadrons planned are to be fighter squadrons. Present plans do not call for maintenance of a strategic bombing force, although the service is being kept abreast of developments in this field.

In the matter of collective security the RCAF is gearing to provide an air division of 11 fighter squadrons for the integrated force under General Eisenhower. One squadron is already in Europe and others are to follow.

Last year saw the revival of Canadian air training for crews from abroad—from Norway, the Netherlands, Belgium, France and Italy (cf. Commonwealth Air Training Plan of World War II). This training here of overseas student air crews is due to expand, to the point where more than 3,000 personnel will be under training annually in addition to Canadian crews.

The expanding Regular Force is backed by a growing Reserve which includes both squadrons engaged on flying operations and ground training units, the latter placing special stress on radar early-warning units. Some operational reserve exercises have been carried out with reserve units in the United States.

Well under way is the RCAF's "Chipmunk Scheme" a refresher flying training programme handled on a reserve basis which, during the last year, gave refresher training to 600 veteran pilots. De Havilland "Chipmunk" primary trainers are supplied to flying clubs across Canada by the air force and actual instruction, at air force cost, is given by the flying clubs.

Unique in the RCAF training programme is the Survival Training School which operates at Fort Nelson, B.C., and Cambridge Bay, N.W.T., within the Arctic Circle. Service aircrew are instructed in methods of bush and

* Cf. Interavia, Review of World Aviation, Nos. 1 and 2, 1952.

Ottawa.

Arctic survival, training being given by experienced air force men, with Eskimos and Indians assisting. Ultimate aim of the school is to train all Canadian air force aircrew actively engaged in northern flying in survival technique.

Air Transportation

Trans-Canada Air Lines in 1951 placed orders for the immediate acquisition of three more Canadair-Four "North Star" aircraft and signed a contract for the purchase of five Lockheed 1049 "Super Constellations" for delivery in 1953.

The "North Stars," 36-passenger versions for overseas flights, will be placed in service early in 1952 on TCA's international routes, freeing 40-passenger equipment for use on North American routes, making 20% more seat miles available to the travelling public during the coming year on transcontinental and inter-city services. The "Super Constellations" will be operated on TCA's overseas routes.

During 1951, passenger and commodity traffic again reached record proportions. Approximately 980,000 persons flew over TCA's North American and international routes, 18% more than in 1950. The volume of air cargo and air express transported by the airline increased by about 15% to 5,200,000 ton-miles. The carriage of "all-up" mail continued under a new agreement with the Post Office Department, and the amount of mail transportation required of TCA increased by 7% over 1950 and exceeded 4,300,000 ton-miles.

A particularly significant development was the unprecedented strength of passenger traffic during the winter months. There is no doubt that this trend found its roots in the airlines' record of year-round operational regularity. In one month, for example, almost 8,000 flight departures were made throughout the TCA system and of these 88% were dispatched on schedule.

Increased revenues for the whole system of TCA, coupled with close control of the Company's expenses, will result in a substantial surplus for 1951. However, the rising cost of materials and labour now being experienced will tend to depress future earnings.

The tremendous growth of traffic was achieved with little change to TCA's route pattern. The only new service of the year was opened on April 1st, when the Montreal—London route was extended to Paris, to form the first direct link by a Canadian air carrier between Canada and continental Europe.

During the summer the highest frequency of flights in TCA's history was scheduled. On trans-continental and inter-city routes, 500 additional seats daily were made available, an increase of 10% over the peak scheduling of the year before. Winter schedules called for a 20% increase in hours flown over the previous winter. On all services, approximately 14% more ton miles of transportation than in 1950 were placed at the disposal of the public.

Operation of the intensified flight schedules made it necessary to train additional crews, and training will be continued into 1952 in order to provide crews for further flight increases.

No expansion of the existing fleet of 20 North Stars and 27 DC-3s was made. But at the height of the summer, the North Stars were operated at a utilization rate in excess of 9¾ hours a day, a record figure. The fleet as a whole flew more than 24,000,000 revenue miles, an increase of 11% over 1950.

The Lockheed "Super Constellation" purchase will introduce a new type of aircraft into TCA service. They will be capable of meeting all competition on the Atlantic route during the next few years and may well prove the ideal link with the development of turbine-powered aircraft.

During the year, TCA carried approximately 8,000 immigrants to Canada from the United Kingdom and Europe under an arrangement made with the Dominion Government.

Aircraft Industry

Two of the world's finest jet fighters are being produced in Canada, the North American F-86 "Sabre" and the Avro-Canada CF-100 "Canuck."

The "Sabre," is being built under licence by Canadair Ltd., of Montreal, and is in operational use by RCAF fighter squadrons. It is the Canadian air force's standard day fighter, replacing the de Havilland "Vampire III" jet.

The Avro-Canada CF-100 "Canuck" twin-jet long-range fighter, an all-Canadian development, is being produced for the RCAF by A. V. Roe Canada Ltd., of Malton, Ont. A two-seater, the Canuck is designed as an all-weather fighter and is particularly suited to Canadian conditions. All production models are to be fitted with the Canadian "Orenda" engine, also produced by A.V. Roe.

The North American "Harvard" trainer—a single engine piston-driven aircraft for basic pilot training—is still being built in Canada ; in addition, contracts running into millions of dollars have been let for licence-production of the Lockheed T-33 jet trainer. Finally, orders have been placed for the big Beech T-36 twin-engined crew trainer. Canadair has undertaken both the T-33 and T-36 jobs, too.

Canada's aircraft engine industry, which so far has been limited to repair work and only recently began design and manufacture with the Avro-Canada axial jets (chiefly the "Orenda"), will receive a tremendous boost with the entrance of Rolls-Royce into the Canadian manufacturing field with the well-known "Nene" centrifugal type, 1,000 of which are required for the 500 T-33 jet trainers to be built for the air force by Canadair Ltd. The Rolls-Royce engine plant should be in production late in 1952.

Lord Hives, chairman and managing-director of Rolls-Royce, Limited, indicated his company's move to Canada is not temporary when he said a contract has been let for a plot of land on the outskirts of Montreal. It is planned to take Canadians to England, train them there in Rolls-Royce factories and bring them back to Canada to train other personnel.

The Rolls-Royce contract enters into three phases. In the first, complete engines will be imported into Canada from Britain—though there have been moves to get them from France (Hispano-Suiza) rather than entirely from Britain ; in the second, assembly and testing facilities of British- (or French-) made engines will come into operation in Canada. Lastly, Canadian resources for manufacture will be utilized.

AUSTRALIA AND NEW ZEALAND

Melbourne, February.—While the outstanding question for civil aviation in 1952 is to what extent the Australian Commonwealth Government's anti-inflation measures will restrict developments, the chief problem for defence aviation will be to prevent achievement from lagging behind the expenditure allocated to it from the total defence budget—A£181,703,000 for the current fiscal year. Delay in the procurement of certain supplies and shortage of technical staff may accentuate this.

RAAF Development

With Cabinet authority pending (and probable) for an increase of 25 per cent in the overall strength of the force, the RAAF already has approval for an air crew training programme to achieve a 50 per cent increase in air crew intake and a syllabus providing pilot graduation in twelve instead of eighteen months. Operational training will remain with service squadrons and conversion to jet aircraft will be accomplished with DH-115 "Vampire" two seat trainers, a number of which are on order from Britain. Major recruiting problem will be in ground staff technical musterings ; the cause, keen competition from civil industry with its high wage rates. The service enters the new year with a new Chief of the Air Staff, Air Marshal James Hardman, RAF. Meanwhile the service is drawing as much as possible for experience on its units now on active service overseas—No. 77 Fighter Squadron (Meteor jets) in Korea, No. 30 Communications Unit in Japan, No. 1 Bomber Squadron (Lincolns) and No. 38 Transport Squadron (Dakotas) in Malaya.

Aircraft Production and Procurement

Preparations for the production of the English Electric "Canberra" jet bomber by the Government Aircraft Factories are well advanced and the initial Government order for 24 of these aircraft is likely to be doubled in the near future. A contract for production of pressed components (fuselages, wings, tail planes and fuel tanks) has been placed with Chrysler Australia Limited, Adelaide, S.A., who expect to complete tooling by the end of next June. The second big project is production under licence by Commonwealth Aircraft Corporation (private enterprise) of thirty-six (the number is soon likely to be doubled) North American F-86 E "Sabre" jet fighters, powered

Federal Parliament, Canberra.

by Rolls-Royce "Avon" jet engines. For some time at least work will be substantially the assembly of imported components and the modification of airframes to take the "Avon" engine which CAC will manufacture and for which a new testing house is now being built alongside the existing "Nene" engine test house at the corporation's Fishermen's Bend factory near Melbourne. There is little question that the production of CAC's new CA-22 (side-by-side) basic trainer (with slight modifications) will be ordered by the Government for the RAAF. The present 450 h.p. P&W "Wasp Junior" radial engine will almost certainly be replaced by another CAC product, a 500 h.p. geared seven-cylinder engine already named the "Cicada." As this review is being written, no new Government contract has been given to the de Havilland organization which is ending its "Vampire" production programme in its Bankstown (NSW) factory. An "intelligent guess" is that de Havilland's will take over the production of the CA-22 from CAC when the "Sabre" and "Avon" engine projects are in operation.

Delivery of the full order of twelve P2V-5 "Neptune" bombers from the United States for anti-submarine operations should be complete before mid-1952. A prediction is that an order will be placed soon by the Government for a number of heavy transport aircraft, possibly C-119 Fairchild "Packets," if these are available. The new year will also see the initial stages of a five-year plan for the construction of a jet aircraft test field at Lara, near RAAF Station Laverton, Victoria. Linked with this project, which is estimated to cost £3,000,000, is a longer-range plan to transfer to the new site the Government Aircraft Factory and CAC's entire organization at Fishermen's Bend. Initially the field will have a concrete runway of 7,500 ft. with a 2,500 ft. over-run, a flight shed and final assembly workshops. Major portion of this work is scheduled to be completed by the end of 1952 in time for the initial tests of the "Canberra" bomber.

Naval Aviation

The carrier HMAS "Sydney," which has replaced HMS "Glory" in Korean waters, has been given an important combat rôle. "Sydney" and the new carrier "Melbourne" (due in Australian waters at the end of 1952) are being modified to take DH "Sea Venom" jet aircraft. Development planned for 1952 includes establishment of a second naval air station at Scholfields, NSW (the first is at Nowra, NSW) to cope with repair and maintenance and with training. During 1952 several helicopters (probably British-built Sikorsky S-51s) will be added to the RAN's aircraft strength.

Civil Aviation Progress – and Recession ?

In the civil aviation field development has been so marked as to cause concern about the capacity to meet the demand. The latest figures (for the 12 months to June 30th, 1951) show that the number of paying passengers carried by all domestic airlines has risen in five years from 509,190 to 1,706,553 ; miles flown from 17,675,700 to 42,030,289 and freight carried from 5,020 tons to 53,482 tons. Yet staff cuts and financial restrictions are hampering the requisite development of the ground organization. Projects which must now be cut include provision of 79 DME stations, 13 ILS installations, static-free VHF communications for all routes, high-intensity airport lighting systems and equipment of a telecommunications centre at Mascot Airport, Sydney. As contracts for most of the equipment have been let, it is the installation programme that must suffer. GCA installation appears to have been "adjourned to a date to be fixed" and VHF, though in a much better state (about 70% of the routes have been covered) will remain incomplete for some time, thus imposing on operators the penalty of having to equip aircraft for both VHF and medium wave systems.

State versus Private Ownership

The Commonwealth Government has ruled, though somewhat diffidently, that its Labour-inherited airline, TAA, will continue as a Government-owned and operated organization. Promise of a "fair share" of Government mail contracts and traffic is unlikely to be accepted by ANA (private enterprise) as recompense for TAA's continued competition. Main issue in the new year will be fleet replacements which both need to order urgently. TAA, solvent and efficient, must obtain the capital for such aircraft from the Treasury, while ANA turn to their shareholders (some of whom at least are said to be restive at the prospect). Labour spokesmen vow that if the Government "disinherits" TAA, their party, on return to power (always a possibility), would restore its privileged status. The threat carries weight by making heavy expenditure by ANA on new aircraft risky, to say the least. Prime Minister Menzies who has offered the somewhat slender assurance that the competition between the two airlines will be "fair," has yet to make his promised statement on how the Government proposes to deal with the situation.

International Prospects

Figures for international operations by Australian airlines for the 12 months ended 30th June 1951 show steady progress—miles flown 7,748,884, paying passengers 39,087, freight 967 actual tons—and the demand continues to grow. Qantas Empire Airways' accounts for 1951 are reported to show a profit of about £200,000. Increased traffic will come from the proposed Perth—Johannesburg service via Cocos Island which is expected to commence in July next. Again fleet replenishment is the crucial factor. One "Super Constellation" on order is merely provisional and KLM's return to the Pacific scene—on the Sydney-Amsterdam route—promises lively competition. Similarly, British Commonwealth Pacific Airlines (operating profit, £26,470) will find the pace quickened by Canadian Pacific's plan to use Series I "Comets" between Sydney and Honolulu (DC-6Bs between Honolulu and Vancouver probably until Series II "Comets" are available).

The New Zealand Scene

Auckland, January.—The New Zealand Government's thorny question of what to do with the Dominion's National Airways Corporation remains unanswered. Late in November 1951 Civil Aviation Minister MacDonald said the Government was still considering the injection of private capital into the corporation, while retaining a controlling interest. The corporation has reported a profit of £8,000 for the 12 months ended 31st March last, the key to better business apparently being conversion from 15-passenger Lockheed "Lodestars" to 24-passenger Douglas DC-3s. Hopes that the proposed £4,000,000 international airport for Auckland would soon materialize seem to have faded ; Works Minister Gorman, pointing to heavy capital expenditure to which the Government is already committed, announced that the airport would "have to wait." A new three-man air services licensing authority promises the public hearing of all applications, the right of appeal and freedom from political control.

Development of the Royal New Zealand Air Force includes the placing of orders for de Havilland "Vampire" jet fighters and Handley Page "Hastings" transports. From the overall defence allocation of £25,000,000, about 10 per cent, or £2,349,000 has been allotted for Air Force re-equipment.

The Chairman of Tasman Empire Airways, Ltd., Sir Leonard Isitt, is confident of "even better results" in the current 12 months of operations. Operational profit in last annual balance sheet was £16,509, net profit £781. A fifth flying-boat is to be added to the fleet and operations extended eastward to Tahiti. The successful interim operation of the Melbourne–Christchurch service by QEA suggests that the days of the flying-boat on the trans-Tasman route may be numbered, though they may be used on the island route effectively for a long time to come. Like all other operators TEAL will find replacement aircraft a difficult problem.

UNION OF SOUTH AFRICA

Johannesburg, February.—In military as well as in civil aviation in the Union of South Africa, the year 1952 is expected to highlight the growing importance in world affairs of the African continent in general and of the progressive country at its southern tip especially.

Service Aviation

The South African Air Force, with its twenty "Vampire" jet fighters, is at present not an impressive force. South Africa will have to work hard to turn into reality the preparations

Cape Town.

made at present on paper. The year 1952 will certainly bring valuable and modern equipment for the Air Force as a result of the agreement between Washington and Pretoria for the supply of arms to the Union. It is not yet clear exactly what the American assistance—for which South Africa, at her own request, will pay in cash—will be. Fighter aircraft for the SAAF have been mentioned in the first reports about the agreement, but no types or names have been published. Some time ago the then chief of the SAAF, Brigadier Durrant, announced that South Africa, with its long coastline on two oceans, must prepare for an effective coastal air defence and that the ideal aircraft for this purpose would be the Lockheed "Neptune P2V" patrol bomber. Nothing has been heard since but it is generally believed that this type will be included in deliveries from the States under the new agreement.

Nothing has been neglected with regard to the training of SAAF personnel in modern air warfare. The Union's participation in the fighting in Korea with its No. 2 "Cheetah" Squadron provides a nucleus of experienced fighter pilots who on their return to South Africa will be first-class instructors.

Civil Aviation

Two events will dominate the progress of civil aviation with regard to South Africa : the introduction of the de Havilland "Comet" jet airliner on BOAC's Springbok Service, and the coming Australian service between Perth and Johannesburg via the Cocos Islands.

The advent of the jet airliner is of special importance to Africa. Even if one takes into consideration the time which will be lost in the "Comet's" frequent landings between London and Johannesburg, the reduction in travelling time from the fog of the Channel coast to the sun of the Transvaal will be a note-worthy event in civil aviation. With the appearance of the "Comet" jet, newer and faster piston-engined aircraft of other airlines are expected to come into operation on the Africa run for competitive reasons. Sabena and KLM may pit the Douglas DC-6B against BOAC's "Comet," though the ultimate goal of the Hollanders will be the introduction of the Lockheed 1049 "Super Constellation," which is expected to accomplish the flight from Amsterdam to Johannesburg in two hops, with one stop at Kano.

Australia's intention to fly across the Indian Ocean to South Africa, as soon as the Cocos Islands is ready, means that South Africa will cease to be a dead-end air terminal. Air travel from Britain and America to Australia will in future be possible via South Africa and traffic to the Union therefore will increase. Up to now, air traffic between the United States and the Union did not justify participation by South African Airways under the bilateral agreement with the United States, but they may be tempted to show their flag in New York when traffic from the States to South Africa develops as part of the new lateral air connection across the Indian Ocean. The Union Government have already given permission to the Australians to inaugurate this service from Perth to Johannesburg, to which South Africa will give no financial aid but will supply the necessary landing facilities. There is no doubt that, apart from the commercial aspects of this new route, it will be of military importance of the first order.

South African Airways will continue to improve their internal network by the use of Douglas DC-4s, which became redundant on trunk routes after the introduction of the "Constellations." It remains to be seen if plans for the use of at least one DC-4 for a coach service to Europe, at reduced fares, will materialize in 1952. Preparations for such a "controlled experiment" are well in hand in South Africa. At present only one private operator, Pan African Airways, is providing a coach service at cheaper rates, with "Tudor" 60-seater planes flying non-scheduled, twice monthly, between the Union and the United Kingdom.

Ground Facilities

South Africa's first modern international airport, Jan Smuts Airfield, will be opened at least partially in the New Year, a "conditio sine qua non" for the operation of the "Comet" to Johannesburg. Of national airports in the Union, the new Reunion aerodrome at Durban has been opened, while Cape Town is still waiting for its Bellville airfield, the construction of which has been delayed in favour of Jan Smuts and Reunion. Other landing grounds on internal routes, such as Port Elizabeth and East London, are at present being modernized.

Private Flying

Not too good are the prospects for private flying in South Africa. The clubs are in financial difficulties and are still waiting for the financial aid promised by the authorities long ago. Training of pupil pilots for the Defence Force under a Government scheme gives some assistance, but altogether the outlook for the private airmen is not rosy and warnings about a resultant shortage of future pilots are increasing. High costs for replacements and a general shortage of spare parts and engines, as a result of the armament race in the world, are making things even more difficult.

SOUTH AMERICA

The year 1951 was one of the most difficult in the life of South America's aeronautics, for both civil and military aviation. Budget cuts and dollar shortages forced numerous countries to halt the expansion of their air forces and air transport systems and to drop the procurement plans established for 1951.

Argentina

The Argentine Government has now elaborated the details of its five-year plan for civil and military aviation. This plan will enter into force on June 4th, 1952, the beginning of the new term of General Peron as President of the Argentine Republic. The gist of this plan is as follows :

I. Military Aviation

a) Construction of new air bases and airfields, as well as of auxiliary air strips which will also be at the disposal of the commercial airlines ; *b)* improvement to existing air bases and airfields, particularly in the southern part of the country ; *c)* improvement of telecommunications and navigation aids, in some cases by the installation of radar equipment ; *d)* expansion and improvement in the training of personnel.

II. Private and Sporting Flying

Reorganization of private and sporting flying by the creation of three federations, namely, one embracing all glider flying organizations, one for power flying clubs, sporting flying organizations, etc., and one for model flying clubs. The three federations will be autonomous but will receive Government subsidies and other forms of assistance.

It is also planned to open elementary and advanced training courses and to encourage the formation of permanent staffs of instructors and engineers for private flying, on to which the commercial airlines may fall back in case of necessity.

III. Aircraft Industry

It is understood that under the second five-year plan (June 4th, 1952—June 30th, 1957) the Instituto Aerotécnico will continue production of the "Pulqui II" jet fighter, put into production the Rolls-Royce "Derwent" engine and the "Calquin" twin-engined ground attack aircraft, as well as a number of gliders, especially the "Clen Antú." It is also possible that a private company will be formed with a capital of 1,000,000 pesos for the manufacture of light aircraft ; at the moment, however, no details are available of the new firm, the types it plans to produce or any Government subsidies it might receive.

IV. Imports

Prospects for the import of aviation equipment are dim because of the lack of foreign

Buenos Aires.

exchange. The Air Force is not planning to buy any fighters, bombers or transport aircraft. Its budget will allow it merely to buy spare parts and accessories. The same applies to private and commercial aviation. New restrictions issued by the National Bank permit the importation of aircraft, engines and spare parts only from countries which have concluded "barter trade agreements" with Argentina, such as Italy, France, Great Britain, Czechoslovakia, etc., but not from dollar zone nations.

V. Commercial flying

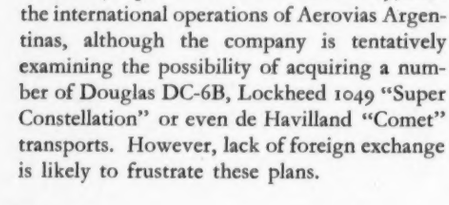
The national flag air carrier, Aerovias Argentinas, today possesses one of the largest air fleets in South America, consisting of 18 Douglas DC-3s, 6 DC-4s, 6 DC-6s, 5 Model 240 "Convair-Liners" and 5 Short "Sandringham" flying-boats. But owing to the lack of spare parts the company has had to reduce its domestic schedules. Aerovias Argentinas has asked for an appropriation of U.S.$2,000,000 for 1952, against U.S.$1,500,000 in 1951, for the acquisition of spares and engines. On international services, the company will not increase any of its frequencies or open any new services ; it merely plans to extend its Rome service (which, incidentally, now terminates at Lisbon) to Tel Aviv or Beirut, but this plan is still subject to Government approval. On internal services the traffic volume in 1951 increased 35% over 1950, and Aerolineas Argentinas is hoping to replace the DC-3s with DC-4s ; here again, the project is limited by the capacity of the airports and runways in certain parts of the country. On completion of work at the airports of Rio Gallegos, Mar del Plata and Tucuman, services to these points may be operated with "Convair-Liners."

No major purchases will be made in 1952 for the international operations of Aerovias Argentinas, although the company is tentatively examining the possibility of acquiring a number of Douglas DC-6B, Lockheed 1049 "Super Constellation" or even de Havilland "Comet" transports. However, lack of foreign exchange is likely to frustrate these plans.

Brazil

The situation of Brazil's air arm and air transport system is quite different from that of the air services of other South American countries. The Brazilian Air Force is closely connected with the United States Air Force through the U.S. Military Mission, directed by General Webster.

Rio de Janeiro.



I. Air Force

The programme of the Brazilian Air Force seems to be composed of the following items for 1952: *a)* No new combat unit will be formed, owing to the lack of qualified personnel ; *b)* a number of transport units equipped with Curtiss C-46 and Douglas C-47 aircraft may be established for the purpose of exploring new air routes to and in the hinterland of the Amazon River ; *c)* the Brazilian Air Force may buy a few Boeing B-17 and B-29 bombers for crew training purposes ; *d)* no jet aircraft will be acquired, owing to lack of foreign currency ; *e)* procurement of flying equipment and spares is to be limited to about U.S.$1,000,000 ; *f)* some North American AT-6 trainers will be bought ; *g)* combined exercises with the ground forces and the Navy will be held in 1952 with the participation of North American B-25 light bombers, Republic F-47 fighters and other World War II types ; *h)* a paratroop unit is to be organized.

II. Civil Aviation – General

Plans for 1952 comprise : *a)* Establishment of a chain of airfields and air strips in the Amazon valley region ; *b)* promotion of the Directorate-General of Civil Aviation to the status of an Under-Secretariat reporting to the Air Ministry ; *c)* creation of new Government-subsidized regional air services which cannot be operated economically by private enterprise ; *d)* formation of new Government-subsidized aero clubs, chiefly for the training of pilots ; *e)* purchase by the Government of 100 light aircraft for the aero clubs and other sporting flying organizations ; *f)* increase in the subsidies payable for Brazil's international air services from Cr. 70,000,000 to Cr. 100,000,000.

III. Commercial airlines

The 1952 development prospects are favourable. The Government has worked out a plan providing for *a)* an intensification of the domestic air services ; *b)* an intensification of the subsidized services to neighbouring countries, Argentina, Bolivia, Chile, Peru, Paraguay, Uruguay and Venezuela ; *c)* a limited expansion of the Brazilian services to the United States ; *d)* the inauguration of new services to Europe by Panair do Brasil, the PAA affiliate, which is the Government's chosen instrument for this purpose.

In the field of domestic operations it is planned to merge a number of operators in order to limit destructive competition and to discourage the formation of new companies (equipment, qualified aircrew and engineering personnel are lacking).

IV. Imports

Imports of aviation equipment must be sanctioned by the Government, but no Brazilian operating concern can afford to import aircraft at the free rate of 28 to 30 Cruzeiros to the dollar. In consequence, 1952 imports will be limited to *a)* spare parts for the commercial airlines for a global amount of U.S.$2,000,000 ; *b)* 100 lightplanes, Pipers or similar types, for the Government ; *c)* 80 to 100 heavier touring aircraft (Ryan "Navion," Beech "Bonanza," Cessnas, etc.) at free dollar exchange rates ; *d)* airport equipment purchased in the USA ; *e)* spare parts for Lycoming and Continental engines.

V. Aircraft Industry

The Government factories are the only ones still in production. The factories controlled by the Air Ministry will assemble North American AT-6 trainers and do repair and overhaul work for the Air Force. The Brazilian aircraft industry prospects for 1952 are therefore very limited.

Chile

The Chilean Government has decided to devote particular attention to the reorganization of the Chilean Air Force during 1952, as well as to the construction of new airfields to improve the network of communications between the various regions of the country where other modes of transport are inadequate. Its programme comprises the following points : Improvement of airfields, particularly in the south of the country ; purchase of aircraft for military training purposes ; purchase of a number of Douglas B-26 aircraft for flights to the Easter Islands ; purchase of several Consolidated PBY "Catalina" twin-engined flying-boats for proving flights on the Australia route, which was explored in the inverse sense by Captain P. G. Taylor last year. Finally, combined air-land exercises will be carried out on the Pacific Coast.

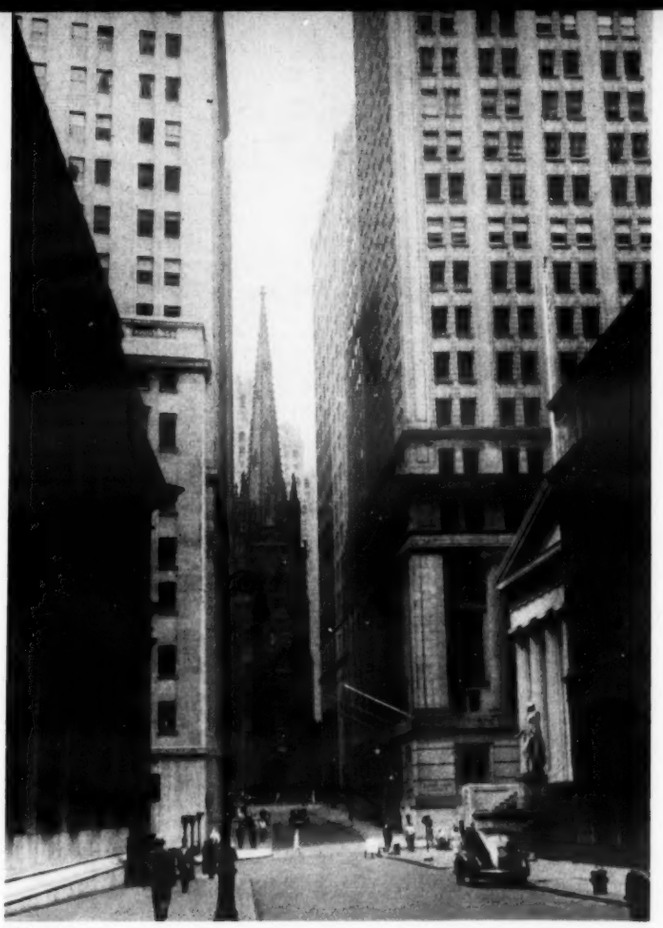
I. Commercial Airlines

Linea Aerea Nacional (LAN) will not be able to expand its foreign air service owing to lack of equipment. On the other hand, LAN will inaugurate a number of domestic services with de Havilland "Doves" bought in England. A new company, *Lyonair,* which started operations in 1950, will increase its overseas cargo flights. Another new enterprise, *LIPAZUR,* which has French capital, will engage in the transport of fish between various points in Chile.

II. Sporting and Private Flying

The Ministry of National Defence, through the intermediary of the Under Secretariat for Air, proposes to subsidize the Chilean aero clubs with money and equipment, particularly by furnishing aircraft and gliders bought abroad. Chile has no aircraft industry, and the purchase of flying equipment is controlled by the Government, which encourages the acquisition of material not involving the expenditure of U.S. dollars.

Aviation Shares on the New York Stock Exchange



Wall Street.

The firm unshaken trend of the New York Stock Exchange throughout the whole of 1951 seems to be getting slightly on the nerves of the stock market prophets. Puzzled, they ask how long the boom—which has already lasted over 28 months—can go on. A. L. Stamm & Co.'s Monthly Stock Digest says for example : "The year 1951 has been one of surprisingly small economic and international changes... It is highly improbable that events in 1952 will be so static."

However that may be, whether the stock market as a whole remains firm or weakens, there is no reason at the moment to believe that there will be any major setbacks in the aviation group. An interesting pointer is that aviation stock was scarcely touched even by the—temporary—recession which set in at the end of October 1951. And the events of the last three months speak without exception for a continuance of today's high prices.

Aircraft industry

In his budget message on January 16th, 1952, President Truman stressed that, in view of the international tension, the American consumer goods industries must again take second place during the next two or three years to rearmament (in credit, raw materials, labour). The President's twelve-point programme expressly included arms aid for Allied Atlantic Powers among these military priorities, so that in all probability the American aircraft industry can continue to count on substantial orders from the U.S. Air Force, the U.S. Navy and the arms aid organization.

The budget proposals for 1952-1953 submitted to the American Congress on January 21st, entirely reflect this defence programme. Out of a total budget of $85,400,000,000 nearly three-quarters are destined for defence (U.S. armed services, arms aid, atomic energy programme : total $65,100,000,000). A sum of $11,000,000,000 is requested for the U.S. Air Force, to build it up to 110 groups ; for the Navy ten large aircraft carriers are to be laid down ; ground organization is to have a special appropriation of $3,500,000,000.

Admittedly a budget proposal is not at all the same thing as the definite placing of orders with the various firms in the aircraft industry—particularly as the Presidential elections are just round the corner, and as experience has shown that considerable time can elapse between the approval and the use of credits. But in spite of everything the budget will inevitably have a stimulating effect. It shows the relative importance accorded to aviation in the total economy of the American nation.

*

The outlook for the American aviation industry would therefore be "set fair," if it were not that the annual report for 1951 presented by Admiral De Witt C. Ramsey, President of the *Aircraft Industries Association,* warns against over-optimism. Admiral Ramsey forecast that the fifteen leading aircraft, engine and propeller manufacturers in the United States would close the 1951 fiscal year with substantially smaller net profits, despite greatly increased sales (the AIA estimates that the total sales for these fifteen enterprises rose from $1,809,000,000 in 1950 to $2,500,000,000 in 1951). Why then should profits fall ? Admiral Ramsey's report gives the following reasons : increased excess profits tax, increased delivery delays resulting from shortage of raw materials and machinery, strikes, rising wage rates and, last but not least, a very marked increase in the cost of training new employees.

To begin with the personnel. During 1951 all companies vied with one another in offering higher wages and better working conditions. This trend by no means seems to have reached its end. For example, North American Aviation Inc. gave the 26,000 workers at its Los Angeles and Fresno (California) plants a cost-of-living increase of 3 cents an hour, dating from January 28th, 1952. The same increase is also planned for the 10,000 workers at the Columbus (Ohio) plant, so that the company's total monthly wage bill will be increased by $124,000. On the same date Northrop gave a wage increase of no less than 12 cents an hour, which is to be paid to all its 14,000 hourly paid employees back to October 15th, 1951... However, in spite of all these increases the labour problem is still far from having been solved. Recently even the Canadian industrial centres of Montreal and Toronto have been getting considerably worried because the American aircraft firms have been trying to entice away their skilled workers.

The present shortage of raw materials, tools and machinery for the expanded production programme produces not only the delivery delays mentioned by Admiral Ramsey, but also leads to sudden capital investment which in normal circumstances could be spread out over much longer periods. There has therefore been a greater call on bank credits in recent months. Some of these are for very large sums, such as 50 or even 100 million dollars. These may not present any very great difficulties to some of the leading concerns, but may well be a heavy burden on smaller enterprises.

Apart from these small flaws, the American aviation industry can doubtless be regarded at the moment as "sound." If nevertheless Stand-

ard & Poor's Corporation Stock guide marks most stocks as "speculative," this is entirely due to the fact that the aircraft industry is still, after all, an armament industry. In this respect no fundamental change can be expected until the aircraft has become the accepted means of travel for the common man. The recent decision to introduce second class services on the broadest possible scale should mean a good step forward in this direction.

*

As for prices, the stock of five firms (Bendix, Boeing, Douglas, Lockheed, United Aircraft) considerably exceeded the maximum prices reached in the years from 1946 to 1950. The only exception to this general upward trend was The Glenn L. Martin Co., who found itself faced by certain difficulties at the end of the year and is to be reorganized. Particular interest was also shown, for example, in the shares of the electronics industry (General Electric, Bendix, Westinghouse, etc.), whose sales rose from a total of $241,000,000 in 1939 to an estimated $2,200,000,000 in 1951.

Newcomers to the Stock Exchange are the shares of Northrop Aircraft and Solar Aircraft, which have previously been dealt with on the Curb Exchange and over the counter respectively.

Air transportation

As was to be expected in view of the boom conditions that have existed during the past two years, air transportation was also among the sought-after groups on the New York Stock Exchange. Unlike the industry, however, none of the air transportation shares again reached their highest prices for 1946-50, and there was even a slight fall in these stocks in the early part of January, 1952.

This holding off is certainly not due to any decline in the airlines' traffic performances. Apart from a decrease during the first two years after the war, the number of passengers has been steadily on the increase. Passenger-miles increased (in each case ower the previous year) by 12% in 1949, 18.8% in 1950 and roughly 28% in 1951. For the first time passenger-miles on domestic air services exceeded Pullman passenger-miles on the railroads: 1946: 30%; 1947: 50%; 1948: 54.3%; 1949: 71.8%; 1950: 85.3%; 1951 (estimate taken from the Aviation Bulletin of John H. Lewis & Co.): 102.5%.

Similarly receipts (from domestic services) increased from $2,300,000 in 1948 to $24,400,000 in 1949, $62,500,000 in 1950 and (estimated) $100,000,000 in 1951.

Despite these more than satisfactory results, air transportation's future profits do not at the moment appear to be altogether certain. Under CAB's new policy, mail payments are difficult to forecast. The results to be expected from the new overseas second class services to be started in the spring of 1952 cannot be calculated in advance. Wages and salaries of flight and ground personnel have risen steeply, in some cases after stubborn battles. Some of the larger companies, such as American Airlines and TWA will have large sums to pay in excess profits tax. Finally, almost all the airlines will be obliged to renew their air fleets, to provide the extra speed required for first-class services and the extra space needed for second class services.

	Current assets in Mill. $	*Current liabilities in Mill. $*	*Cash and equivalents in Mill. $*	*Dividends 1950*	*Already paid 1951*	*Price on Dec. 31st 1951*	*High 1951*	*Low 1951*	*Highest price 1946-1950*
Aircraft industry									
Beech Aircraft	26.0	21.4	2.63	0.80	0.80	12 3/4	14	10 3/4	25 5/8
Bell Aircraft	40.5 [5]	32.2	3.1	1.75	2.25	34	33 1/2	22 7/8	35 1/2
Bendix Aviation	143.7	66.1	.	5.00	3.00	51 1/2	59 7/8	46 1/2	58
Boeing Airplane	116	70.1	26.0	3.00	3.00	44 3/4	56	39	41 7/8
Consolidated Vultee	61.4	30.8	10.6	1.00	1.40	17 1/4	21 1/4	14 1/2	33 5/8
Continental Motors	44.1	19.4	15.6	0.40	0.50	9	11 1/2	7 3/8	24
Curtiss-Wright	121.1	24.6	72.6	1.00	1.00	9 1/4	12 1/8	8 1/2	12 1/2
Curtiss-Wright "A"	.	.	.	2.00	2.00	23 3/4	27 3/8	23 1/4	.
Douglas Aircraft [1]	106.1	53.6	19.7	3.12	3.50	57 5/8	66 7/8	43 1/2	54 1/2
Fairchild Engine & Airplane [3]	25.5	9.83	7.96	0.60	0.40	7 1/8	9	6 1/2	9
Grumman Aircraft Engineering	46.4	23.5	16.4	2.00	2.00	23 1/2	27 7/8	19 1/2	29 3/4
Lockheed Aircraft [1]	95.0	63.5	20.1	1.50	1.10	22 1/8	25 7/8	16 5/8	22 5/8
Glenn L. Martin	46.3	41.5	6.62	.	.	12 1/4	21 5/8	11	45 1/2
McDonnell Aircraft Corp. [4]	22.8	14.3	4.12	1.00	1.00	20	22 1/4	15 5/8	.
North American Aviation	60.7	15.2	13.3	1.25	1.25	15 5/8	19	13 3/4	18 5/8
Northrop Aircraft	21.2	13.1	9.2	.	0.50	14 3/4	17	11 1/2	15 1/2
Republic Aviation	21.0	14.1	6.17	0.50	1.00	13 7/8	16 3/4	10 7/8	24 7/8
Ryan Aeronautical [3]	6.99	3.15	0.74	0.20	0.40	10	10 1/2	7 1/2	.
Solar Aircraft	15.1	10.7	0.98	0.60	0.80	20 1/8	23	12 5/8	25 5/8
United Aircraft Corp. [2]	147	56.6	28.9	1.67	2.00	31 5/8	34 1/4	26 1/2	31 3/8
Air transportation									
American Airlines	36.4	23.3	16.7	0.25	0.50	16 7/8	17 1/8	13 1/8	19 7/8
Braniff Airways	7.96	5.10	3.06	0.25	0.50	14 3/8	16	12	34 5/8
Capital Airlines	7.57	6.74	3.79	.	.	15 3/8	17 1/4	12	45 3/4
Eastern Air Lines	31.5	15.7	15.4	0.25	0.50	23 3/8	30	19	33 3/8
National Airlines	6.93	6.35	2.69	.	0.50	16 5/8	17 1/4	12 1/4	34 7/8
Northwest Airlines	15.9	13.2	6.62	.	.	15 3/4	16	12 1/8	56 1/2
Pan American World Airways	77.7	57.3	41.6	0.50	0.50	11 3/4	13 1/8	9 5/8	27
Trans World Airlines	32.6	24.0	18.5	.	.	24 1/8	27 7/8	19	71
United Air Lines	42.2	29.1	28.0	0.75	1.50	33 5/8	35 5/8	22 5/8	54 1/4

[1] After splitting of shares. [2] Excluding special payments. [3] Curb Exchange. [4] Over-the-counter. [5] Recent capital changes.

What's in the Air ? *

AVIATION POLITICS

Italy

● At the end of December 1951, Italy denounced the *political, military and industrial clauses of the Peace Treaty*. Although not all 20 signatories to the Treaty were in agreement (in particular Russia and the rest of the Eastern bloc were missing), the Italian Foreign Minister had the support of Britain, France, the United States and eight smaller states. Thus the former *limitation of the Italian Air Force* (25,000 men, 350 aircraft, no bombers) *is lifted*, as are also certain *restrictions on the Italian aircraft and armaments industry*.

● According to reports in Milan's "Alata," the Italian Navy has already drawn up a *development programme for guided missiles*.—Italian industry is expecting to receive armament orders to the value of 20,000,000,000 lire. Rumours that the output of the Italian aircraft industry is to be limited would therefore seem to be unfounded, in particular since export orders for 7,000,000,000 lire (primarily for trainers and jet engines ; main firms concerned, Fiat and Aeronautica Macchi) are already in hand.

Spain

● *Spain* and the *Philippines* have concluded a *bilateral air agreement based on the "fifth freedom."*—A French delegation has been in Madrid to discuss the organization of a Franco-Spanish search and rescue service for the Western Mediterranean.

Scandinavia

● On December 30th, 1951, *Sweden, Norway and Denmark* signed an *air agreement* in Oslo, which considerably *simplifies frontier formalities* in air transport between the three countries. Under the agreement, Scandinavian aircraft need no entry permit to any of the Scandinavian countries. It also guarantees close cooperation between the aviation authorities of the three States.

Sweden

● In the *Swedish defence estimates for 1952-1953* (Kr. 1,405,000,000) the Swedish Air Force is to get credits of Kr. 512,354,000. Of this sum, Kr. 320,000,000 is to be earmarked for aircraft procurement.

INDUSTRY

France

● The French Government aircraft works, *SNCA du Sud-Est*, and the American firm of *Sikorsky Aircraft Corp.* (helicopter division of United Aircraft) signed a licence agreement on January 16th, 1952, authorizing SNCASE to produce the Sikorsky S-55 helicopter. A first batch of 200 of these helicopters is planned. Georges Héreil, Chairman of SNCASE, an untiring advocate of European unity, is said to be planning to give sub-contracts for components to Italian and perhaps even to German firms.

● The Brazilian Government has authorized a Brazilian aircraft accessories supplier to import 120 French touring aircraft, of the Nord 1200 "Norécrin" type.

Spain

● The well-known Spanish aero engine firm of Elizalde S. A. has been renamed Empresa Nacional de Motores de Aviacion, on Government instructions, and attached to the Instituto Nacional de Industria. Engineer Modesto Aguilera has been appointed managing director.

Great Britain

● At the 16th Annual General Meeting of the *Hawker Siddeley Group Ltd.* T.O.M. Sopwith, Chairman of the Board, gave a remarkably realistic picture of the *present situation in the British aircraft industry*. Despite the fact that research and experimental prototype development in Britain had "led the world for years," the RAF still has to fly obsolescent aircraft. There were three main reasons for this : *time required for production* (the Hawker P.1067 swept-wing jet fighter took three times as many manhours to produce as the "Hurricane" of World War II) ; *longer delivery period* for raw materials (nine months for light metals, 15 months for stainless steel, 16 months for copper, brass and bronze) ; the *most serious* bottle-neck is the shortage of skilled labour, and the Group has started a national advertising campaign to attract labour to its factories. (The British Minister of Labour is preparing, with the support of the Trades Unions, a bill to control the movement of labour, so that jobs can only be obtained through the Employment Exchanges. Editors.)

Accession of Elizabeth II
Following the death of His Majesty King George VI on February 6th, Princess Elizabeth was proclaimed Queen of Great Britain and Northern Ireland and the British territories overseas, and Head of the Commonwealth. The late King was himself a military pilot and Marshal of the Royal Air Force.

Canada

● *In spite of an increase in sales* of 18% *De Havilland Aircraft of Canada Ltd.*'s net profit fell from $324,698 in 1949-1950 (up to September 30th) to $165,046 in 1950-1951. The annual report remarks that controlled profits on armament orders are disappointingly small.

USA—Japan

● Plans for the *re-activation of the Japanese aircraft industry* gradually appear to be getting beyond the stage of theoretical discussion. According to reports from Yokohama, an agreement is shortly to be signed, under which Douglas will give the five leading Japanese firms repair work for the U.S. Air Force's Far Eastern units. A survey team from Bell Aircraft Corp. recently visited the Shin Meiwa and Fuji Sangyo works, to investigate the possibility of having helicopters built under licence in Japan.

AIR TRANSPORTATION

International

● In a New Year message Sir William P. Hildred, Director-General of the International Air Transport Association, estimated the number of passengers carried by scheduled airlines during 1951 as 39,000,000, an increase of 30% over the previous year.

● Figures released by the International Air Transport Association show that 1951 brought by far the greatest increase in passenger demand since 1946 :

1947-1948 + 12%	1949-1950 + 18%
1948-1949 + 12%	1950-1951 + 25%

In other words the number of passengers on the world's air routes has increased by 85% since 1947 ; freight

The well-known French aircraft manufacturer *Louis Bréguet* has been made Grand Officer of the Legion of Honour for his pioneer achievements in aeronautical research.

Edward H. Heinemann, engineering chief of Douglas's El Segundo (California) works, the designer of the *Douglas D-558-2 "Skyrocket"* record-breaking rocket aircraft, has been awarded the *Sylvanus Albert Reed Prize* for 1951 by the Institute of the Aeronautical Sciences.

On January 22nd, 1952, the British Minister of Civil Aviation handed to the de Havilland Company the *certificate of airworthiness for the "Comet" jet airliner. At the table* (left to right) ; Mr. J. S. Maclay, Minister of Civil Aviation ; F. T. Hearle, Chairman of the de Havilland Company ; R. E. Bishop, a director of the Company and designer of the "Comet." – *Back row* (from left to right) : R. E. Hardingham, Chief Executive of the Air Registration Board ; Sir Arnold Overton, Permanent Secretary to the Ministry of Civil Aviation ; Air Chief Marshal Sir Frederick Bowhill, Chief Aeronautical Advisor to the Ministry ; W. E. Nixon, Managing Director of the de Havilland Company ; F. E. N. St. Barbe, Deputy Managing Director ; A. F. Burke, Managing Director of the de Havilland Engine Company.

* Extracts from "Interavia Air Letter," daily international news digest, in English and French. All rights reserved.

Bristol 173 twin-engined helicopter for 13 passengers or 2,500 lbs. freight.

Night fighter version of the Russian MiG-15 jet fighter. Picture (no cheating!) shows a MiG-15 night fighter shortly after taking off from an East German base.

transport increased in the same period by 203% (from 297,000,000 tonnes-km in 1947 to 900,000,000 tonnes-km in 1951).

USA

● The U.S. Civil Aeronautics Board has prepared the following restrictions on the number of passengers and crew to be carried by commercial aircraft :

Douglas DC-6 :	87	Lockheed 649-749 :	69
Douglas DC-3 :	31	Martin 4-0-4 :	45
"Convair 240" :	51	Curtiss C-46 :	67
Lockheed 1049 :	94		

● In a preliminary report for 1951 Pan American Airways estimates its passenger total as 1,289,000 (compared with 1,018,000 in 1950), freight as 77,059,000 lbs. (55,400,000 lbs.). The company expects that trans-Atlantic traffic (second class) will increase by over 100% in 1952, and also plans to introduce second class services in the Pacific.

Douglas DC-7 four-engined airliner for 60 to 95 passengers.

● The U.S. Civil Aeronautics Administration has set up a commission to investigate the problem of suppressing aircraft and engine noise in the neighbourhood of airports. Charles F. Horne, CAA Administrator, is chairman. The following have been asked to cooperate : the Air Transport Association of America, the Aircraft Industries Association, the Airlines Pilots Association, the Airport Operators Council, as well as members of the U.S. Air Force and Navy.

FIRST FLIGHTS

● *North American Aviation* is working on the development of the *XA2J-1* "*Savage*" twin-engined bomber and low-level attack aircraft for the U.S. Navy (see elsewhere in this issue). The first of two prototypes has been completed and began its flight tests at the beginning of the year. The XA2J-1, which is designed for carrier operations, is a development of the North American AJ-1, also built for the Navy. However, whereas the AJ-1 is fitted with two piston engines and a turbojet (in the rear of the fuselage), the XA2J-1 has two Allison T-40 propeller turbines of at least 5500 shaft h.p. each, driving two pairs of Aeroproducts contra-rotating three-blade propellers. Folding wings and a pressure cabin for a crew of three are other features.

● The *Chance Vought F7U-3* "*Cutlass*" twin-engined tailless carrier fighter (Westinghouse J-46 turbojets of 6000 lbs. = 2700 kg thrust each, with afterburners) has started flight tests. The F7U-3 is the final version of the F7U and is now in quantity production. It is slightly larger than the original F7U-1 version and also has heavier armament than its predecessor.—Chance Vought has also begun flight tests of the *AU-1*, the latest version of its well-known F4U "Corsair" naval fighter and low-level attack aircraft.

● In Canada flight testing of the *De Havilland-Canada DHC-3* "*Otter*" small commercial and general purpose aircraft has begun. The "Otter"—formerly known as the "King Beaver"—is an all-metal high-wing monoplane for civil and military use (landplane or seaplane version, or with skis) ; 8 to 14 passengers can be carried. Derived from the successful smaller model, the DHC-2 "Beaver," the DHC-3 is fitted with Pratt & Whitney R-1340 "Wasp" engine of 600 h.p.—*Bristol*, of Great Britain, has announced the first flight of the *Bristol 173* twin-engined helicopter (tandem rotors). The machine, which is fitted with two Alvis "Leonides" engines of 550 h.p. each took off for the first time on January 3rd.—From France comes news of the first flight of the *SIPA S.200* jet-powered light sports and training aircraft (Turboméca "Palas" of 330 lbs. = 150 kg thrust). The two-seater S.200 (seats side-by-side) is of all-metal construction, has a short fuselage, retractable nosewheel undercarriage, two tail booms and twin rudder unit, but single elevator unit. For a gross weight of 1610 lbs. (730 kg) the S.200 is said to have a cruising speed of 236 m.p.h. (380 km/h) and a range of 280 to 435 miles (450 to 700 km).

NEW AIRCRAFT

● At the end of 1951 *Douglas Aircraft Co.* announced the *Douglas DC-7* four-engined commercial transport, a development of the well-known DC-6. At the same time a first order from American Airlines for 25 of these aircraft was announced—projected entry into service January 1st, 1954. Fitted with four 3250 h.p. Wright R-3350 "Turbo-Cyclone 18" compound engines, the DC-7 will have a maximum speed of over 400 m.p.h. (640 km/h) and a cruising speed of roughly 360 m.p.h. (580 km/h). Projected versions : for 60 passengers (long-range over-ocean services ; gross weight 122,200 lbs. = 55,430 kg) ; for 95 passengers (American domestic services ; gross weight 116,800 lbs. = 52,980 kg). Absolute range in long distance operations 5350 miles (8610 km) at 10,000 ft. (3050 m) and 5175 miles (8330 km) at 20,000 ft. (6100 m). The corresponding ranges of the 95-passenger version are 3625 miles (5830 km) and 3500 miles (5630 km). The purchase price of a DC-7 is $1,590,000. Its span is 117 ft. 6 in. (35.8 m) like the DC-6, DC-6A and B ; length is 108 ft. 11 in. (33.2 m) compared with 100 ft. 7 in. (30.7 m) in the DC-6 and 105 ft. 7 in. (32.2 m) in the DC-6A and DC-6B.

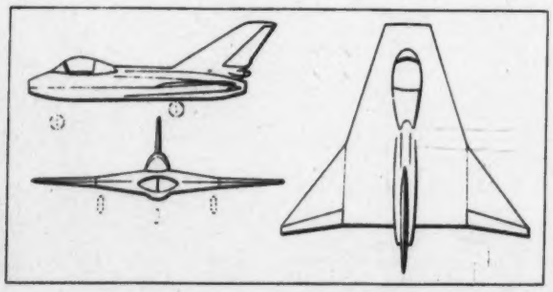
● *Consolidated Vultee* has received a U.S. Air Force order for a *YF-102 delta wing supersonic fighter*. This is probably a development of the Convair XF-92A experimental machine now flight testing.—*Avro-Canada* is also working on a *project for a delta wing fighter* for supersonic speeds. Avro-Canada, well-known for its CF-100 twin-engined all-weather jet fighter, gives a calculated maximum speed of roughly 1000 m.p.h. (1600 km/h) and a cruising speed of over 700 m.p.h. (1100 km/h) for the new type.—In Sweden the Saab 210 "Draken," a small *delta wing experimental aircraft* of *Svenska Aeroplan A.B.* fitted with an Armstrong-Siddeley "Adder" jet engine of 1100 lbs. (500 kg) thrust has started its flight testing at Linköping (cf. also INTERAVIA, Review of World Aviation, No. 2, "The Flying Triangle"). Whereas the two former deltas have been developed as operational aircraft, the Saab-210 is a purely experimental type for low speeds.

● The *Tupolev TU-4* (also known as the TU-70 or TU-29), which can still be regarded as standard long-range bomber of the Russian Air Force, now appears to be coming into operation in a *troop transport version*.—It is reported from Eastern Germany that a *night fighter version* of the well-known *Mikoyan MiG-15* high performance fighter has been in use for the first time. The chief difference in the new type is the radar blister above the air intake in the nose (similar to the North American F-86D "Sabre" which also has a frontal air intake and radar equipment in the nose).

POWER PLANTS

● *Rateau SRA 101* is the designation of a high power jet engine (8800 lbs. = 4000 kg take-off thrust with water injection), which is now undergoing bench test at *Société Rateau*, La Courneuve (Seine).—*Société Turboméca*, of Bordes (Basses-Pyrénées), known for its successful series of small power turbojet engines, is said to have received a *development contract for a high performance jet engine* of 13,230 lbs. (6000 kg).

Saab-210 "Draken" delta-wing experimental aircraft.



Omni-Ranges for Long Distance Navigation

by Dr. Ernst Kramar, C. Lorenz AG., Stuttgart

The general tendency of developments in radio navigation aids is to produce systems which translate the pilot's position in space into direction and distance from his target. In the American Instrument Landing System and the " omni-range airways " on short distances (VOR/DME), such a system has already been introduced, making allowance for increasing speeds of flight. The following article will show that omni-ranges can also render valuable service in long distance navigation, with very simple equipment in the aircraft. Editors.

As early as the autumn of 1946 the Provisional International Civil Aviation Organization issued recommendations for radio aids to long distance navigation [1], which, however, it has not yet been possible, in spite of the technical efforts made, to put into practice satisfactorily. There has been no lack of suggestions. Lower standards are even required of the equipment than for short distance and landing procedures (in which the time available to the pilot for readings is so short that indicators must be particularly clear and simple). The difficulty has been—and still is—the unreliability of the conditions of propagation of the frequency band below 300 kc/s (over 1000 m wavelength), which is the only band suitable for long distances. [2, 3]

Accuracy, reliability, simplicity

The accuracy of 10 nautical miles over a range of 1,000 nautical miles recommended by I.C.A.O. can be obtained, but not with 100 % certainty. This requirement is not even met by celestial navigation—with an average accuracy of 5 nautical miles or better. In the latter the observer can himself as a rule judge the value of the reading and eliminate such obviously false measurements as arise from excessive movement of the measuring platform or other extraneous causes.

In radio navigation over long distances on the other hand it is expected that *every* reading, whatever the conditions under which it is obtained, should be within the above-mentioned accuracy limits. To be able to judge their reliability it is therefore essential that the *quality* of reception should also be indicated. The simple way of doing this is through headphone reception or by means of a visual indicator showing bearing value and quality. In continuous direction finding all sudden deviations from the average reading, due to short-period disturbances, are ignored.

The chief requirements of a long distance system are undoubtedly that the reception equipment in the aircraft should be as simple, as reliable in operation and as light as possible. The equipment should be simple to operate, and the pilot, when approaching or leaving a radio beacon, should be able to work out his direction without the aid of map or reckoner, i.e., be able to read off the wind drift directly.

The last-named requirements, however, can only be met by systems whose lines of equal values are *straight*, not *curved* as in hyperbola systems. They are met by omni-directional radio beacons which, when set up at the beginning and end of the route, enable the pilot to home on the beacon in the simplest possible way on a great circle, by keeping a constant reading on his instrument. Similar beacons, to one side of the route (for ocean routes on islands for example) provide position fixes from time to time and thus enable ground speed to be estimated.

One navigation system which comes close to the above-mentioned requirements, although it works on the hyperbola principle, is the " *Sonne* " system (better known under the name of " Consol "),[4] which was developed during the war for land and sea navigation by C. Lorenz AG., Berlin. Its basic principle is the *production of a fan of equisignal zones* and the combination of a *dot and dash keying* with the progressive *rotation* of this fan. The signals are counted either direct or by means of a supplementary device which enables the results to be read off continuously from an instrument.

Further development of the Consol system

It has now become possible, by using a new aerial arrangement [5], to do away with the interference principle and thus with all the disadvantages which the Consol was recognized as possessing, but which were accepted because of the simplicity and low cost of the system. The advantages of the new arrangement are :—

1) equal bearing precision is assured all round the beacon by 6 equal sectors (the installation is adjusted to North. Evaluation is considerably simplified, since every character counted in the aircraft represents one degree, in relation to the sector in which the observer is situated.)

2) the night error (produced by the ionosphere and its variations in height) which is unavoidable in the interference system, is eliminated ;

Fig. 1a : Range and " unreliable sectors " of Stavanger (319 kc/s). Bushmills (263 kc/s) and Ploneis (257 kc/s) Consol beacons.

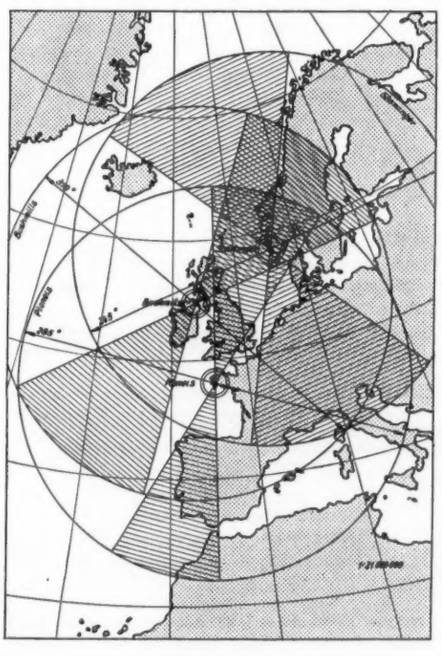
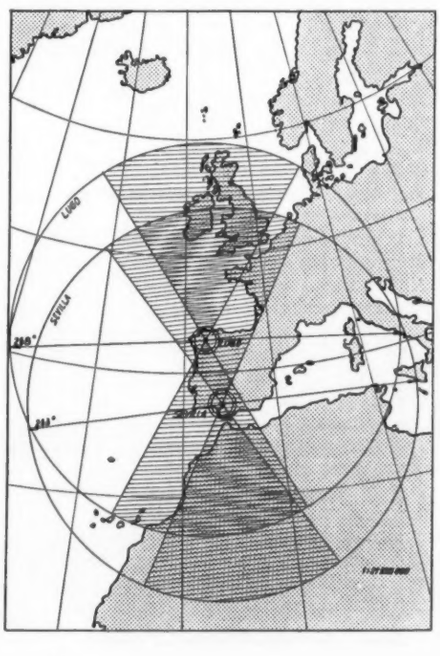


Fig. 1b : Range and " unreliable sectors " of Lugo (303 kc/s) and Seville (311 kc/s) Consol beacons.



3) ambiguity of readings, which produces errors of up to 20 degrees in the Consol, is practically eliminated ;

4) no change in the radiation diagram is produced over a frequency range of ±15%, so that no alterations need be made on the map for changes of frequency within this range ;

5) the aircraft equipment can be used to within very close to the radio beacon (unlike the Consol, where accuracy is obtainable only from about 25 nautical miles on) ;

6) the space required for the aerial is considerably smaller than in the Consol (circle approx. 1.3λ in diameter compared with a distance of 5λ between the outer aerials of Consol), and therefore its site is easier to select.

The following critical examination of today's European Consol network, which was expanded for shipping and aviation after the war by the erection of two new installations at *Bushmills* and *Ploneis*, will help to give a clearer idea of the value of the new system, especially of the advantages listed under 1) and 2). Assuming a range of approximately 1,000 nautical miles, it would look as if the greater part of Western Europe, up to longitude 35 in the Atlantic, is over-well covered for position finding. However, when we bear in mind the so-called " unreliable " sectors of these installations, we get quite a different picture *(figs. 1a and 1b)*. Over a large part of the North Sea and the Bay of Biscay they are in practice utilizable only as non-directional D/F transmitters (NDB), and even on the mainland there are large areas, over which aircraft on long distance continental flights might wish to take bearings, which are inadequately served.

The above remarks apply in particular at *night*, i.e., at times when the effect of sky waves is strong. This disturbing effect is encountered not only in the " unreliable " sectors (hatched), but also becomes increasingly noticeable to either side of the main direction of radiation. The British have issued correction curves, which enable bearing errors at night for a mean ionosphere height to be read off *(fig. 2)*. Statistical measurements carried out by German lightships have confirmed these values, but have also shown how great are the dispersions to be reckoned

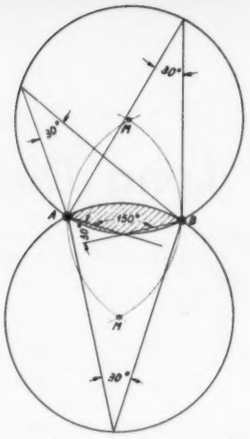
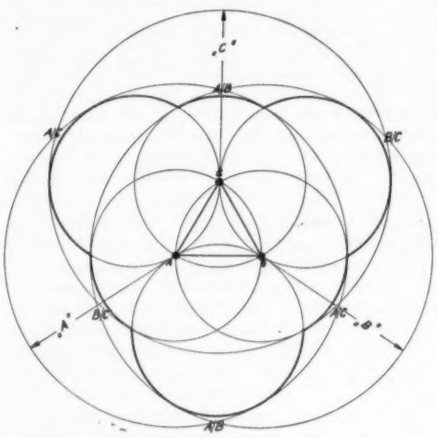


Fig. 3 : Geometrical locus of angles of intersection of over 30° for position finding from two (above) and three (below) beacons. (This requirement is met, except in the hatched area, inside the circles about M_1 and M_2).



with, particularly near the " unreliable " sectors, i.e., to what extent the value of these installations is reduced in these directions by the effect of the ionosphere.

These details show clearly what a great improvement over present conditions could be made by omni-directional radio beacons whose accuracy remains equal in all directions. It was therefore suggested, during the war, that two Consol aerial systems, with their base lines arranged at an angle of 90° to one another and a common centre mast, should be used alternately, each transmitting for one rotation in turn. However, there were three fundamental disadvantages to this proposal, and to a similar one made by O'Brien, the inventor of the Decca System [6], and both were dropped. The time elapsing before the repetition of the same process is doubled ; the maps printed with Consol values became too confusing, particularly when details for at least two beacons were entered, for the purpose of determining position ; and above all there were still night errors in the sectors away from the main direction of radiation.

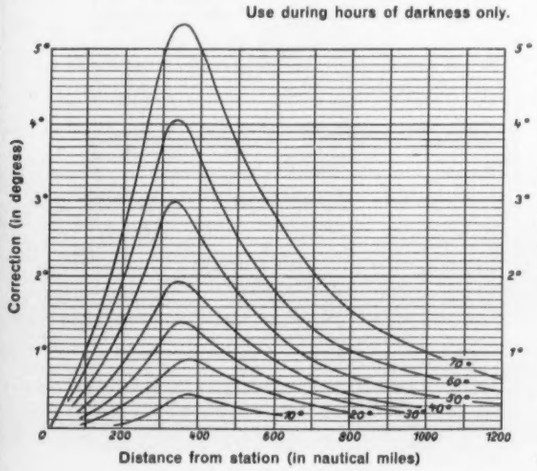
These errors can only be eliminated if the interference principle and its hyperbolas in space (hyperboloid of rotation about the line connecting the masts) are done away with and an aerial system chosen which transmits in perpendicular planes of intersection from the point of origin. To mark the basic difference between this new arrangement and Consol, from which only the combination of keying and rotation of a fan-shaped beam have been taken over, the name LOMOR (*LO*ng Distance *M*edium Frequency *O*mni *R*ange) has been proposed. The actual equipment is described below, preceded by a description of the way in which several omni-directional radio beacons can work together.

A chronic shortage of frequencies in a band in which hundreds of small and medium non-directional beacons also work, in addition to the Consol beacons, raises the question of what would be the *most favourable* arrangement for omni-directional beacons for position finding. If we start with the useful angle of intersection between two base lines of 30° to 150°, we find that the geometrical locus for this requirement is two circles *(fig. 3)*. If a third transmitter is also used, the areas on either side of the line connecting the first two transmitters where there would otherwise be excessively flat angles of intersection, can also be covered. If the maximum range of the beacons (1000 nautical miles) is used as basic scale, the distance between any two transmitters is approximately 500 nautical miles. Their most favourable arrangement is at the vertices of an equilateral triangle. The area covered measures approximately 2.75 million square nautical miles, and about 80% of the area enclosed by the range limit will be available for use in position finding.

If we apply this principle to the European Consol beacons, assuming that they have their aerial system altered to make them into omni-directional beacons, we get a much more satisfactory picture, in particular for the beacons in the triangle of *Stavanger*, *Bushmills* and *Emden (fig. 4)*. In conjunction with Stavanger, the projected German beacon at Emden would provide good position finding conditions for a large part of the Baltic area and, in conjunction with Bushmills, for the North Sea as far as Iceland and, south-westwards, the Channel and the Bay of Biscay. The land areas covered would be useful for continental flights, though here, thanks to the poor propagation conditions over land, the range will be not more than 700 nautical miles. In conjunction with *Ploneis*, Emden would also give satisfactory plots over Western and Central Europe.

In the south-western area *(fig. 5)* the two beacons at *Lugo* and *Seville* are too close together (approx. 300 nautical miles) and can therefore be used only for position finding up to a maximum range of 500 nautical miles in the favourable direction over the sea. With *Ploneis* on the other hand Seville gives good position ranges, which are mostly

Fig. 2 : British correction curves for night errors (sky waves) in Consol installations.



Bearing of normal to line of aerials			
Bushmills	Stavanger	Lugo	Seville
130.2° — 310.2°	067.0° — 247.0°	068.5° — 268.5°	083.0° — 263.0°

Correction is determined from distance from station and " angular difference between bearing and aerial normal line ".

EXAMPLE :

Bushmills normal line	=	130° — 310°
Bearing obtained	=	270°
Angular difference		40°

If distance from station is 400 miles, correction is minus 2 degrees. Corrected azimuth of position : 270° — 2° = 268°.

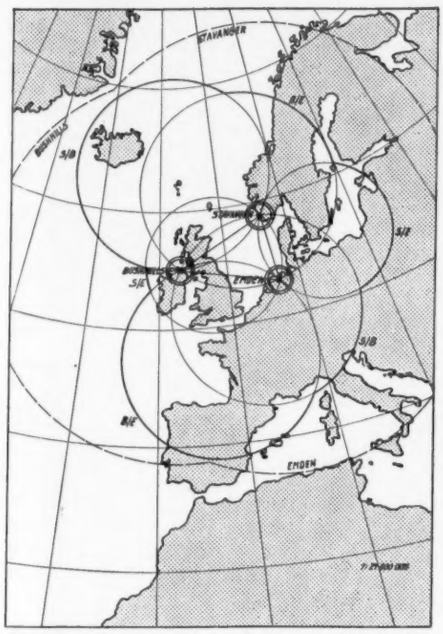


Fig. 4 : Area covered by Stavanger, Bushmills and Emden long distance medium frequency omni-ranges (LOMOR).

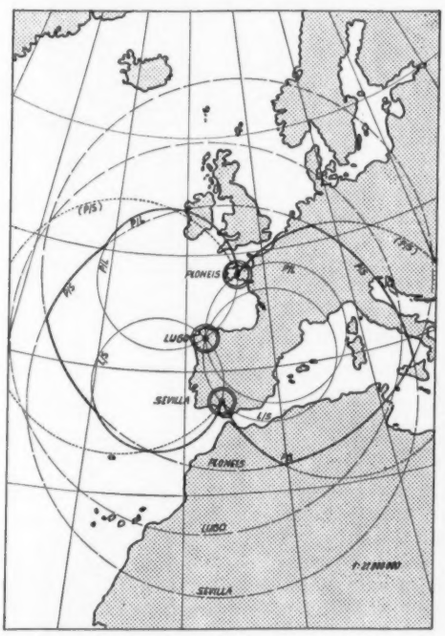


Fig. 5 : Position finding and determination of position line from omni-ranges at Ploneis, Lugo and Seville.

limited by the propagation line, whilst Lugo is of little value as navigation aid, even when used in conjunction with Ploneis.

In international planning therefore the best solution will be to arrange the long distance omni-ranges roughly in equilateral triangles with a side of about 500 to 600 nautical miles.

Fig. 6 shows how simply the network could be expanded over the North Atlantic. A beacon on Newfoundland would give shipping and aviation position lines from New York to the middle of the Atlantic (roughly as far as longitude 30) and meet up here with the European beacons. Another installation in the Azores or Iceland would enable position fixes to be obtained over a large part of the North Atlantic air routes, the Azores installations—together with the Spanish—also providing a useful navigation aid for South Atlantic routes. This shows that these beacons even meet the requirement that the system should be capable of expansion for world-wide use.

In connection with the shortage of frequencies it may be pointed out that such omni-directional beacons satisfactorily replace non-directional beacons of relatively high power (NDB) for direction finding and homing, since they continuously transmit a carrier wave. The carrier is emitted both during the keying period and during the continuous dash period, in the latter case simultaneously with the station's call sign. The omni-ranges could also replace the high power medium frequency four-course beacons now commonly in use.

Principle of long distance navigation system

As in the Consol system, the long distance omni-directional beacon consists of an unmodulated transmitter with a power of approx. 5 kW, its power supply, keying and goniometer equipment and instruments for monitoring. On the other hand the aerial system is new, and consists of two concentric groups of aerials, one group inside the other, each with 6 masts approx. 165 ft. high (diameter of circle approx. 1.3 times the wave length) and the corresponding counterpoise (earthing network) and supply cables. Existing Consol installations could therefore be converted into this type of beacon at relatively low cost.

To describe the functioning of the system we shall start from a group of six masts, which transmit six equisignal planes at equal intervals of 60 degrees. This fan-shaped beam is produced by phase keying of two six-leaved clover diagrams, so that the 60° sectors are marked alternately by dots and dashes. By means of a slowly rotating goniometer arrangement and continuous transmission of power from the first group of aerials to the second, these sectors are rotated regularly by 60 degrees within one minute (or half a minute). During this rotation a total of 60 characters is keyed. Each character therefore corresponds to the movement of the radial equisignal zones through one degree. When the process is complete, a switch mechanism sends out for a certain length of time a non-directional continuous dash, interrupted by call signs.

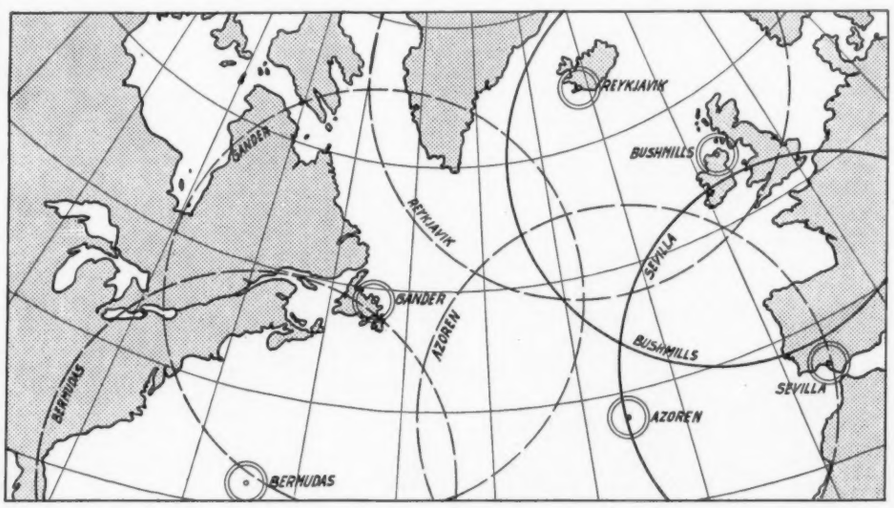


Fig. 6 : Proposed site for additional omni-ranges in the North Atlantic
——— stations in use — — — — proposed stations

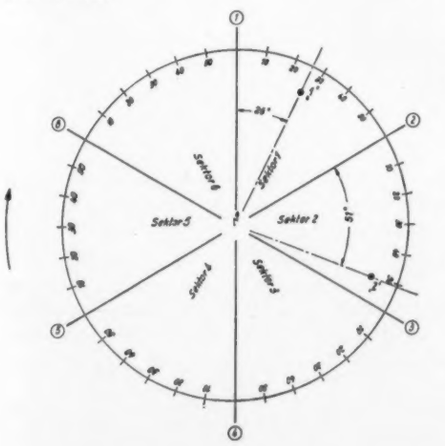
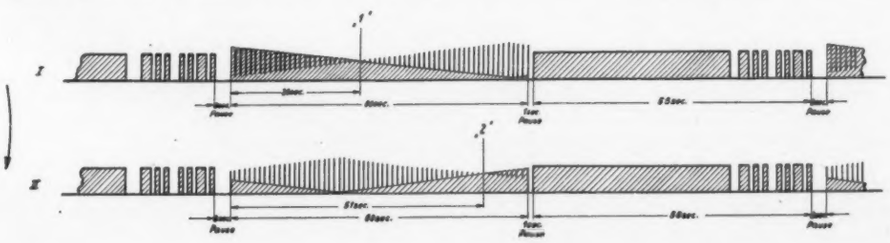


Fig. 7 : How a long distance omni-range works.
At the beginning of each keying period an observer hears dashes in sectors 1, 3 and 5 and dots in sectors 2, 4 and 6.

I and II show the sequence for an observer " 1 " in sector 1, and observer " 2 " in sector 2 respectively.



After a few seconds' pause the sequence is repeated.

As in the Consol the observer (in the aircraft) counts the characters from the beginning of the keying period up to his passage through the equisignal zone *(cf. fig. 7)*. The number of characters indicates directly the azimuth of the position—in degrees in relation to the sector. In the first sector in fig. 7 the observer (" 1 ") first hears dashes and then, after passing through the equisignal zone, dots ; in the second sector on the other hand (" 2 ") he will hear first dots and then dashes. The third sector behaves like the first. The system thus has an ambiguity of 120 degrees, which is immaterial in long distance navigation. As already mentioned the signals can be counted automatically and indicated continuously on a special instrument.

Conclusion

The above remarks show that the combination of keying and rotation of a fan-shaped beam, proved satisfactory in the Consol system, produces, in conjunction with a new aerial system, an omni-directional radio beacon for long range navigation whose advantages are above all that it can be used without restriction in all directions, has equal position finding accuracy and is largely independent of night error. Thus the defects hitherto connected with the Consol system are overcome. Evaluation is even simpler than in Consol ; all that is needed in the aircraft is a medium frequency receiver or D/F apparatus (always available).

The examples given in the European and Atlantic zones show what astonishing progress could be made in the safeguarding of shipping and air navigation by this system of omni-directional beacons, for which the name of LOMOR has been suggested. In view of the shortage of frequencies in the medium and long wave range it is interesting to note that omni-ranges of this kind could replace today's non-directional beacons for homing and direction finding, as well as the four-beam course beacons.

[1] PICAO, Jan. 1947, Doc. 2553, COT/26 : Long Distance Aids to Air Navigation.

[2] *P. Adams and R. Colin :* " Frequency, Power and Modulation for a Long-Range Radio Navigation System " ; Electrical Communication, Vol. 23, 2/1946.

[3] *Caradoc Williams :* " Low Frequency Radio-Wave Propagation with reference to long distance navigation " ; Proc. Inst. of Electrical Engineers, March 1951, Vol. 98, p. 81.

[4] *G. Guanella :* " The Consol Navigation System " ; Interavia, Review of World Aviation, Vol. I, 1946, Nos. 4 & 5.

[5] Patent applied for by C. Lorenz AG. on May 27th, 1944.

[6] *W. J. O'Brien :* " Radio Navigational Aids ", Journal of the British Institution of Radio Engineers, 1947.

Fire-Fighting at Airports

by J. L. Jacob, Paris

Modern airports have become veritable cities faced not only with the dangers directly connected with the operation of aircraft, but also with the same risks as occur in large industries. The latter, however, are intensified by the nature of the operations carried out, the size of the buildings and the value of the equipment they house, and last but not least, the large number of people using the airport.

Fires at airports can be divided into three categories :—

I. Fire in the buildings.

II. Fire in an aircraft on the runway, without other accident.

III. Fire in an aircraft as the result of an accident, outside the runway but inside the aerodrome zone.

Fires in Buildings

A large part of an air terminal's buildings is given over to administrative offices, reception premises for passengers, baggage, freight and Customs offices. Although the danger of fire is perhaps reduced owing to the fact that there is almost always some personnel on duty, it is increased on the other hand by the presence of passengers and visitors whom it is sometimes difficult to persuade to observe the essential rule against smoking. Another difficulty is presented by the Customs and police rules regarding access to certain parts of the buildings. Fire-fighters must be fully acquainted with these so as not to come up against the barriers and locked doors which separate all international airports into two zones, and may necessitate considerable detours with consequent delay in getting at the fire.

In buildings connected with the parking, maintenance and repair of aircraft fire risk is considerably greater because of the possible causes of fire and the quantities of fuel always present in these buildings. The fire service here has three main tasks, namely *prevention, detection and warning*, and *extinction*. If we consider the speed with which a fire can spread inside a hangar or an aircraft repair shop, thanks to their size, we shall appreciate the full value of preventive measures intelligently planned and strictly adhered to in practice.

Fire prevention inside buildings

Electrical installations of all kinds, both fixed and above all mobile, must be fitted according to the strictest rules and inspected at regular intervals. No inflammable material, such as wooden beams, partitions, floors, or combustibles, may be permitted on the premises. Modern engineering has produced a vast quantity of materials to meet all the requirements of architecture, decoration and comfort (sound and heat insulation) while being fire-resistant and thus contributing to general safety. Such materials include for example hollow building panels filled with glass wool. Heating systems must be efficient but absolutely safe. This recommendation is not needed for modern airports, but is still valid in the case of older or provisional installations.

Kerosene and fuel-oil stoves are widely used because of their efficiency, but are not without danger. The control tower of a large international airport was nearly destroyed in this way a short time ago. Electric fires should also be banned for the same reason.

The great majority of fires are caused by carelessness or ignorance of danger, so that the establishment and enforcement of strict safety regulations is essential. These will include :—

— Prohibition of smoking,

— Special care of oily rags, and prohibition of the use of sawdust to dry up oil leaks etc.,

— Compulsory precautions in connection with all high temperature work, such as arc welding, blow-lamp work etc.,

— Safety measures for cellulose paint sprays,

— Earthing of all electrical equipment,

— Regular inspection of all power and light tables.

(A serious fire was once caused at a French dockyard when a portable lamp—with no protective globe—was broken when the air was filled with petrol fumes.)

In spite of all precautions fires will still sometimes occur, and the problem of extinguishing them therefore remains an important one.

Detecting a fire and giving the alarm

If a fire is to be put out effectively prompt measures must be taken. This means that it must be possible to locate any fire immediately it starts.

Although, as we have said above, there is almost always some personnel on duty at an airport, this obviously does not apply to all parts of the airport and all times of the day and night. A fire may start in part of the premises which is not frequently used, or where nobody works at night, and may burn unperceived for some time.

Some form of automatic warning device is required, a system which is reliable, rapid and connected to a permanently manned point from which help can be sent immediately, before the disaster has had time to spread. Modern fire-fighting methods will be chosen for their efficiency, speed and simplicity of operation. The actual substance used to extinguish the fire should also cause as little damage as possible.

Extinguishers

The various types of fire extinguishers are too well known to require description here. Foam, soda-acid, carbon dioxide snow, methyl bromide and tetrachloride, and powder apparatus all have the required properties to varying degrees. Hand extinguishers may be supplemented by vehicles of 10, 20 or 40 Imp. gallons capacity for foam, or 40 to 120 lbs for carbon dioxide apparatus. In the majority of cases of simple fires, these extinguishers should suffice.

Fire hydrants (with flexible pipes of canvas, rubberized canvas, rubber reinforced with steel spiral, or flexible metal pipes) will provide effective aid, but have the inevitable disadvantage that the vast quantities of water used, frequently far greater than are strictly required to put out the fire, will also cause damage. The use of atomized water reduces this disadvantage and at the same time speeds up extinction, and it is to be hoped that it will find the same favour in Europe as it already enjoys in America.

In cases of serious fire, the airport fire services should be called in. These will use classic fire-fighting methods, though their equipment must, as shown below, be specially adapted for use on aircraft both on and off runways.

Fires in Aircraft

Although the problem of fires in buildings is a serious one, it concerns in practice only material goods and does not normally endanger human life. Because of the size of the buildings and the fact that they have few stories, the problem of saving life rarely arises. Also, fire-fighting equipment is at hand, the possible points at which fire might break out are known, and fire drill has been held.

Fire in an aircraft, however, is a different matter.

— Human lives, frequently a large number, are in danger.

— The site of the fire cannot be foreseen.

— Fire-fighting equipment, for the most part, is far from the fire.

Fires occurring during filling of tanks

These endanger both the aircraft itself and the fuel truck. Among the principal causes are errors in the gauges which lead to a tank overflowing, carelessness in emptying tanks, static electricity which produces sparks and sets light to the petrol fumes rising from the tank.

Danger to life is limited to the personnel, but the risk is serious because of the large quantities of fuel present.

Only large-scale extinguishers are of any use here, such as can rapidly cover the whole of the affected area with the extinguisher substance. The use of hand extinguishers would be futile. There are two types of substances used here, non-persistent and persistent.

Non-persistent substances are all the gaseous products whose efficacy results from the creation of a zone of non-inflammable gas, combined with more or less intense cooling. These systems work very rapidly but their effect is brief, since the gas or vapour is dispersed by the wind and the convection currents produced by the fire. If the fire has therefore not been entirely put out there is a risk of its re-starting.

The most commonly used substance is liquid carbon dioxide, in high pressure bottles (steel or special light alloys). On exit into the open part of the liquid expands and vaporizes, producing intense cold. Another part freezes, because of the fall in temperature, and is converted into a solid. Thus the extinguishers spray a mixture of CO_2 gas and solid CO_2 in the form of very cold snow (—75°). The fire is therefore put out by cold and smothering.

The bottles, each containing 40 to 60 lbs, or more rarely 100 lbs, are carried in groups on fast motor vehicles of varying capacities (from the jeep to a 3½-ton chassis). A collector connects the bottles to one or several distributor nozzles operated by hand or mounted on a swivelling carriage in the front of the vehicle.

This method, alongside a number of advantages, has the disadvantage that the equipment is heavy, its range is relatively small, and its efficiency strongly influenced by the wind and above all by the temperature, since the amount of snow produced decreases as the temperature increases. At 31.5°, CO_2's critical point, the quantity is very small, and above 40 to 45° it falls to zero.

An American variant of the system consists in keeping the liquid CO_2 under low pressure in a single large tank, at a very low temperature and under a pressure of 18 lbs.

In this way a very high delivery volume is obtained, and the cooling and amount of carbon dioxide snow produced are considerable.

Atomized water may also be regarded as a non-persistent substance. In this process the water droplets are very small and remain suspended in the air in the form of water fog. The amount of heat absorbed by the atomized water is considerable. However, the method is only really useful for the protection of the immediate surroundings of the fire. It cannot always be relied on to put out the actual fire. The pressure required is at least 13 lbs.

*

Persistent substances are fire-extinguishing substances which are not blown away or destroyed during the actual fire-fighting. At the moment only foam offers the qualities required.

In essentials foam is an emulsion of gas in a liquid medium—generally water—with a capillary attraction such that the gas remains in the liquid in very fine globules. The whole produces a paste-like substance, very light, adhesive, a poor conductor of heat, and not destroyed by fire.

The emulsion can be produced either chemically or mechanically.

Chemical foam is produced by the reaction of two appropriate solutions with a base of

Mechanized fire-fighting. A 49,000 lb. truck belonging to Northrop Aircraft Inc. It carries 6000 lbs of carbon dioxide and 500 gallons of water, and has a total of 14 fire spray nozzles suitable for either carbon dioxide or water.

aluminium sulphate (active solution—A) and bicarbonate of soda (base solution—B), with the addition of a foam-producing substance. The carbon dioxide which results from this reaction both produces and propels the foam. The reaction is provoked by upsetting or shaking a hand extinguisher or one on wheels, but the inevitably limited capacity of these apparatus renders essential the use of more powerful equipment, namely foam generators, with continuous delivery.

Foam generators consist of a large tank and a hydraulic apparatus; water inlet under pressure attached to a flexible pipe; a method of mixing powder with the water; and a distributor system with spray nozzles. — The only difference between the various types of generators lies in the method of adding the powder.

One of the simplest systems is the vacuum *injector*—Venturi or Giffard. This creates a vacuum which sucks in the powder and mixes it with the water. The dissolving of the grains of aluminium sulphate and bicarbonate of soda in close proximity produces an instantaneous reaction, and foam is immediately sprayed from the nozzle. However these injectors can become blocked if some of the powder sticks together, or if a foreign body accidently gets into the tank. The equipment then breaks down, must be emptied and the injector cleaned. Another disadvantage is that if the canvas exit pipe for the foam is accidentally obstructed (bent, run over by vehicle, etc.) the water runs back into the tank full of powder, the reaction takes place there and the apparatus floods, putting itself temporarily out of service.

A considerable improvement has been made by a French firm which has replaced the vacuum injector by one using centrifugal force to introduce the powder into the water stream. The stream of water from the nozzle covers a certain distance in the open, during which time the powder, properly measured out and treated, falls into the water. Centrifugal force acting on this relatively heavy powder ensures homogeneous and rapid dispersal of the dry powder in the flattened stream of water. The equipment thus is not subject to the troubles which handicap the vacuum injector.

Mechanical foam: outwardly *air foam extinguishers* do not differ from those using chemical foam. However, the gas used is not carbon dioxide but air introduced *mechanically* into the water to which a foam-producing substance has been added.

The apparatus comprises a water inlet under pressure, a means of introducing the emulsifier, and an air inlet. The three elements can be mixed and the foam projected from the same apparatus, or the various processes may take place at several different points.

The simplest type is a *foam spray*, comprising connection to a flexible water feed pipe, multiple injectors to suck in the emulsifying liquid and the air and mix the three substances. This is very simple, but can only be used near the emulsifier tank. The emulsifying liquid can also be introduced by means of a *pump*, since feed pipes give the vehicle all the mobility it needs.

Fire occurring during engine starting

Despite all possible precautions it happens fairly frequently when the engines are being started up, especially in cold weather, that there is a flash-back that ignites the fuel in and round the carburettors. Since engines are not started up until the passengers are on board, it is obvious that action must be immediate and discreet, so as to avoid causing panic.

Foam extinguishers cannot be used here because of the arrangement of the engine cowlings and the difficulty of cleaning the engine afterwards. Only a non-persistent substance is suitable, and up to the present the most popular has been carbon dioxide.

The quantity required is small since the fire is contained inside the cowling. The best equipment to use will be a mobile extinguisher with a capacity of 20 to 45 lbs, with a rigid pipe 10 to 12 feet long, and a spray nozzle at the end. A trigger cock in the handle of the pipe permits of instantaneous operation.

While the engine is being started an operator stations his extinguisher to the right of the engine and places the spray nozzle against the air inlet to the carburettor. Should a fire start, a pressure of the finger on the trigger opens the cock and releases the carbon dioxide snow, which immediately puts out the fire.

During the particularly cold winter of 1949-50, there were no less than 18 fires of this kind at a certain French airport on one day. Thanks to this equipment not a single departure was delayed and none of the passengers noticed anything untoward.

Fire accompanied by accident, on or off the runway

The fires dealt with above are relatively harmless in comparison with those resulting from a crash landing. The danger to the passengers, the large quantities of fuel present, the fact that the site of the accident cannot be predicted, the suddenness of events, all complicate matters considerably.

Success here depends on both equipment and personnel. The *equipment* must have :—

speed
adaptability
independent operation
immediate effectiveness.

The prime factor in success is speed, whether it is a question of an accident on take-off (due to loss of speed) or on landing (bad visibility), a belly landing, or any other type of accident, damage to the fuel tanks causes parts or the whole of the aircraft to burst almost instantaneously into flames. A matter of seconds, or minutes at the most.

The fire trucks must be able to move at high speed, both on runways and across country. This means that there must be close cooperation between the designers of the vehicles and the producers of fire extinguishing equipment. A minimum speed of 45 m.p.h. is required.

Equipment must obviously be at permanent readiness. Drill should be carried out several times a day, and engines warmed up at regular intervals during cold weather.

Trucks must be able to operate over all types of country. In addition to powerful engines, they must be built on the three-axle principle, with proper load distribution and wheels with good grip on soft ground. Two engines will be required, one to propel the truck and the other to work the extinguishers.

All this equipment must be independent of outside aid. This applies particularly to equipment incorporating a water pump. The speed of operation required makes it impossible to use a hydrant outside the truck, which must carry a sufficient quantity of water itself or in a trailer. In some cases an auxiliary tank truck may be held in readiness for an emergency, but should not be used at the outset, so as not to hamper the main fire truck in its tactics. The fire truck (or group of trucks) must also bring with it all equipment required for approaching the fire, life-saving and clearing away the wreckage. Such equipment is useless unless it arrives immediately.

Speed of extinction is the prime necessity. Operations in this case do not last long, since it is a fight against time to save first lives and then the aircraft. The attack must be short and sharp.

The equipment used will be similar to that described above, but with special provision for the different conditions of use. Here again the choice is between methods using non-persistent and persistent substances. The former are rapid, but involve the risk of re-ignition; the latter are reliable, but less instantaneous in use.

Up to the present carbon dioxide snow has been the primary non-persistent substance, but now a new French product known as " Kaogène " appears to have completely revolutionized the problem. The substance is produced by the solution in liquid carbon dioxide of certain salts, already known but apparently never used for this purpose, with the aid of a dissolvant.

A greater cooling effect on the less volatile particles of the composition virtually doubles the power of the jet, and general efficiency, thanks to the oxygen-destroying effect, is about four times as great as that of carbon dioxide snow.

Except for connections and spray pipes, the equipment used for the new substance is the same as for carbon dioxide snow. Fire extinguishers in the aircraft, using carbon dioxide, can also be adapted for Kaogène.

*

Both chemical foam and air foam have their partisans. However, the air foam method would appear to have a slight tactical advantage, in spite of the fact that it is less persistent. But the transport of large quantities of powder for the chemical foam is always a difficult problem, even when a container with automatic delivery control is used. To make a cubic yard of foam 25 lbs of powder are required but only 15 lbs of emulsifier.

*

The American forces use a heavy vehicle, known as Crash Truck P.155, which carries four tons of water, two independent engines and two swivelling " Monitor " nozzles. In many cases the nozzles originally provided for water have been converted to use air foam.

In France three firms have developed a number of smaller, lighter trucks, whose smaller capacity is compensated by their greater speed. Some of them carry both carbon dioxide extinguishers and foam generators.

Jeeps and Dodge 4×4 chassis have also been equipped for this purpose. Thanks to their low cost they can be used in larger numbers and the fire thus attacked simultaneously from several points.

An important part is also played by the cross-country type of vehicle. In France at the moment production is being concentrated on an apparatus for a capacity of 200 litres of compact foam, with independent suspension wheels and 600×16 tyres (jeep type). This apparatus can be towed by a jeep or a Dodge 4×4 at a speed of easily 55 m.p.h. On rough ground its qualities are excellent. It can cross ditches and holes, and surmount obstacles of a foot or more in height.

Personnel

It need not be stressed that fire-fighting personnel must be thoroughly trained and of the highest quality. Speed, precision, initiative, quickness of decision, a high sense of duty and spirit of sacrifice are essential.

Constant strict training, and frequent drill on real fires are indispensable, since only in this way can the qualities be obtained on which the preservation of life and property depend.

Photo credits :

Front cover : British Crown Copyright ; pp. 127-131 : U.S. Defense Dept. (4), British Crown Copyright (1), Boeing Airplane (1), North American Aviation (1), Central Press (2), Interavia Records (8) ; pp. 132-137 : factory photos, Intreavia Records ; p. 138 : Interavia Records ; pp. 139-143 : factory photos (6), author (2), Interavia Records (2) ; pp. 144-145 : British Crown Copyright ; pp. 146-147 : Ryan Aeronautical Co. ; pp. 148-150 : Weltraumfahrt (1), H. Hähnel (1), Institut für wissenschaftliche Filme (1) ; pp. 150-154 : Interavia Records ; pp. 157-158 : R.C.A.F. (1), Clichés Richter (1), factory photos (7), Interavia Records (1) ; pp. 159-162 : author ; pp. 162-165 : Interavia Records.

Fokker

S. 14

SIDE BY SIDE

JET TRAINER

SPECIALLY DESIGNED FOR THE TRAINING
OF JET FIGHTER PILOTS

N. V. KONINKLIJKE NEDERLANDSCHE VLIEGTUIGENFABRIEK
AMSTERDAM

For your 1951 (Vol. VI) issues of
INTERAVIA REVIEW

our

Binding Covers

Imitation leather with gold lettering
are now available

Price, including postage and packing :
Switzerland : Sw. frs. 6.50. Foreign countries : Sw. frs. 7.50

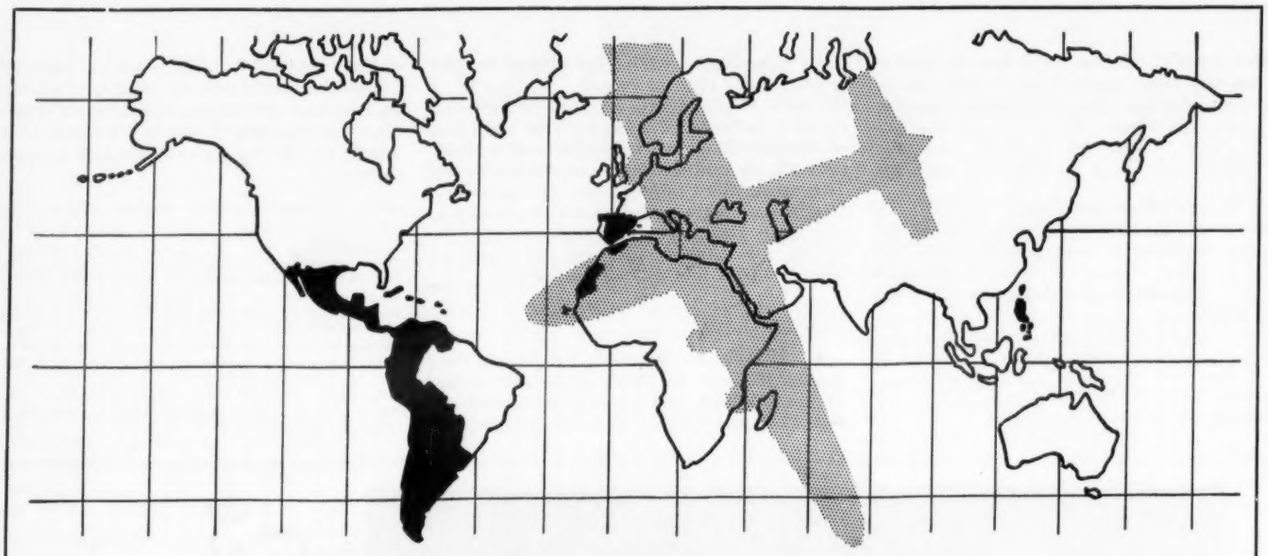
INTERAVIA S. A.
6, CORRATERIE GENEVA SWITZERLAND
Swiss postal cheque account No. I. 5380 Geneva

GENESE

ABG

BOUGIES
RAMPES
MAGNÉTOS
VIBREURS
RÉGULATEUR D'AVANCE

DEPARTEMENT AVIATION 3, IMPASSE THORETON - PARIS XV

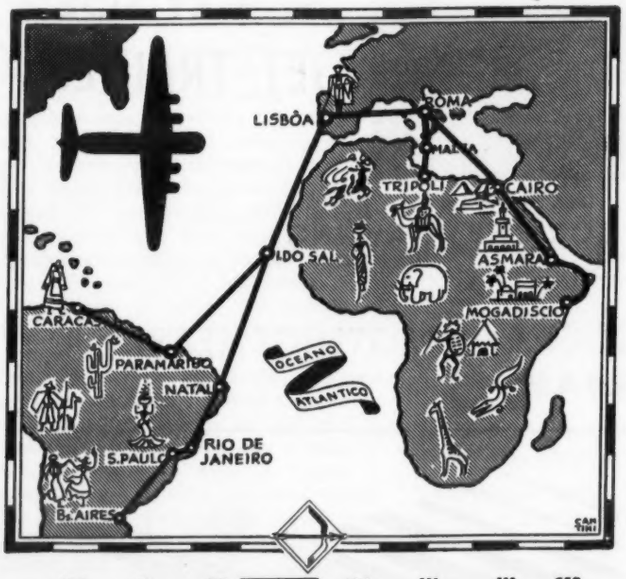


Over 120 million people speak Spanish !
You can reach them on the aircraft of

IBERIA

LINEAS AEREAS ESPAÑOLAS

From Madrid to : Buenos Aires, Caracas, Porto Rico, Havana, Mexico, Paris, London, Geneva, Rome, Lisbon, Canaries, Tangier, Spanish Marocco and the whole of Spain.



ALITALIA

Rome - Via Bissolati 20 - Tel. 470 541

Fast, reliable services by four-engined SUPERMASTERS
On board : first-class Italian cuisine - free air mail service

Information and Reservations from your favourite travel agency or from :

ALITALIA passenger agency - **Rome** - 15 Via Bissolati - Tel. 470 241
Telegrams : ALIPASS-ROMA

ALITALIA passenger and freight agency - **Milan** - 1, Via Manzoni - Tel. 12 626
Telegrams : ALIPASS-MILAN

ALITALIA freight agency - **Rome** - 39, Piazza Augusto Imperatore - Tel. 67 095
Telegrams : ALIMERCI-ROMA

PILATUS AIRCRAFT WORKS LTD.

STANS, Switzerland

Tel. (041) 84 14 46

Design and Manufacture of Civil and Military Aircraft, Production of Parts, Components, etc. — Contractors to the Swiss Federal Government, Foreign Governments and Airlines. — Swiss Federal Air Office Certificate for all Types of Aircraft up to 11,000 lbs. Gross Weight as well as for DC-3, DC-4 and C-46 Aircraft.

PILATUS AIR SERVICE

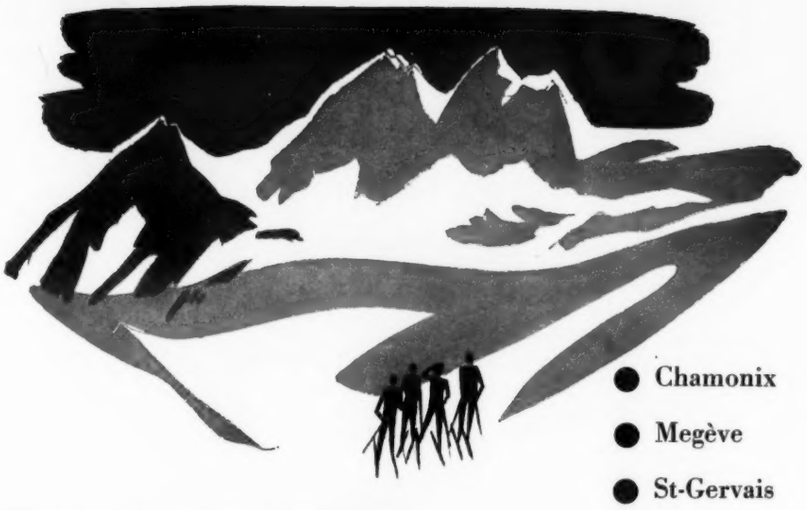
Engineering, Maintenance, Overhaul, Inspection, Repair and Commercial Ground Handling for Irregular and Charter Operators, Taxi and Private Aircraft.

GENEVA-COINTRIN Tel. (022) 2 04 65

ZURICH-KLOTEN Tel. (051) 93 73 87

CAA-Licensed Mechanics for U.S.-Registered Aircraft

- Zermatt
- Montana-Crans
- Verbier
- Villars
- Bernese Oberland
- Gstaad
- Saanen
- Château-d'Œx
- St-Cergue s/Nyon



- Chamonix
- Megève
- St-Gervais
- Morzine

For your winter sports holiday

Geneva international airport occupies a key position in relation to the winter sports centres in Valais and Savoy. By flying to Geneva you save time and prolong your winter holiday. Special direct services to the French centres.

GENEVA

INTERCONTINENTAL AIRPORT

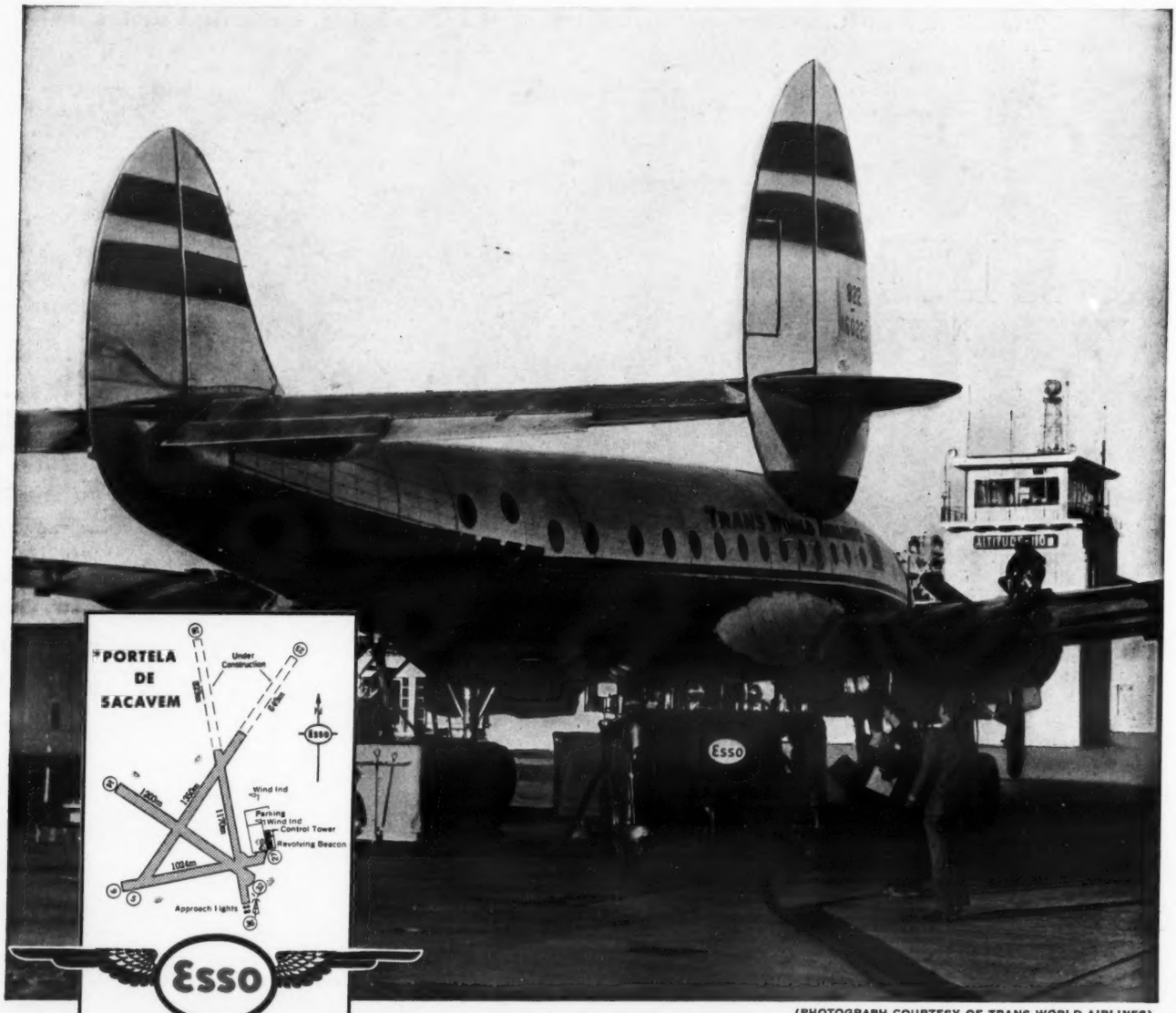
A Good Sign to Fly to...

The ancient city of Lisbon has been a principal port for centuries, located where the Tagus River meets the Atlantic. Many of today's travelers and traders, however, make use of the excellent facilities of Portela de Sacavem Airport, now in process of being greatly enlarged.

Aircraft owners and operators rely on Esso Aviation Products here, close to Lisbon's outskirts, as elsewhere along the airways of the world. These products have been developed by research which goes steadily ahead working out newer and better means of meeting the needs of modern aviation.

The Esso winged oval symbolizes petroleum products of uniform, controlled quality backed by more than 42 years of aviation experience.

*At Portela de Sacavem Airport, as at Santa Maria Airport, Azores, the marketer of Esso Aviation Products is Esso Standard Portugal, Inc.



(PHOTOGRAPH COURTESY OF TRANS WORLD AIRLINES)

ESSO EXPORT CORPORATION, AVIATION DEPARTMENT
45 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.